Advanced ArcView GIS For Resource Conservation Phase II

Produced by Kittitas County Conservation District & Thurston Conservation District
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USDA

Thurston
Conservation District

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Advanced ArcView GIS Applications For Resource Conservation Phase II

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COURSE OBJECTIVES

- Data Acquisition & Conversion
- Project Data Management
- Customization
- Map Design
- Arc View Extensions
- Spatial Modeling
- Spatial Analysis

Course Syllabus
Advanced ArcView GIS Applications for Resource Conservation

Text and Other Resource Materials:

Introduction to GIS for Conservation Districts, Kittitas County & Thurston Conservation Districts
Using ArcView GIS, ESRI
What's New in ArcView GIS, Version 3.2. ESRI
ArcView Spatial Analyst, ESRI

Course Objectives:

Upon the completion of this course, the student will:

A. Know where to get data, convert it and use extensions and scripts.
B. Manage projects and data.
C. Understand the use of grid data and basic Spatial Analysis operations.

Course Content and Schedule:

Content includes lecture, demos, and hands-on training.
Two days (8:30 – 5:00 Day One & 8:00 – 4:00 Day Two)

Day 1
Review and Intro to Advanced ArcView
Data Conversion & Acquisition
Working with Tables
Project Management & Customization
Q&A

Day 2
Project Management & Customization, Continued
Layouts and Cartographic Design
Review/Q&A
Spatial Analyst
Using the Model Builder Extension
Hydrological Analysis and modeling with the Spatial Analyst Extension
Review/ Final Q&A

Statewide GIS Training Project
Phase II

As of June 30, 2000, 20 CDs went through the GIS training program (phase I) in Washington. Twelve additional CDs are applying GIS independently. The Washington Conservation Commission funded Phase II of the training program under the Water Quality Competitive Grant 2000-2002. CD and NRCS technicians will learn additional ArcView applications and management techniques to develop more useful analysis and visual tools, critical to resource conservation planning.

Vision Statement:

1. To make it economically feasible for all interested CDs to apply advanced ArcView GIS applications for water quality conservation planning by the end of the grant.

2. To provide the necessary training for CDs to work independently in GIS.

Project Goal:

The goal of the Statewide GIS Training Project Phase II is to improve analysis of water quality changes resulting from conservation planning and implementation activities in each CD using GIS as a measurement tool.

To achieve this goal Kittitas County Conservation District and Thurston Conservation District will:

- Assess individual GIS needs of interested CDs and help them meet those needs
- Provide all interested districts with consistent, high-quality ArcView training
- Provide ongoing support to districts through networking and conferences

For more details on the Vision Statement and Goals, contact Nicole McCoy (nicole-mccoy@wa.nacdnet.org) or Eric Charlton (eric-charlton@wa.nacdnet.org).

Acknowledgements

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1.0 Data Conversion & Acquisition

What you will learn:

- Resources for data and help
- How to download data from a website
- How to import an ArcInfo coverage using the Import71 utility
- How to use the Arc View Projection Utility

Help and Resources on the Internet

The internet is a very valuable source of data, help and GIS information. The sources listed below are just a start. Many of the sites have additional GIS links, which in turn have more links. Remember that URL's or web page addresses change constantly. If there are links that do not work use a reputable search engine and search with key words.

When looking for GIS data remember that there are generally three types of sources. These include:

1. Government
   - NRCS
   - USGS
   - Counties
   - Cities

2. Data Resellers
   - See the Esri Data Hound page

3. Other Users/Colleagues
   - Other Conservation Districts
   - Tribes
   - Non-Profits

The links provided below are, for the most part, sources of free data. Many Counties and some of the State agencies may ask you to pay for their data to cover duplication and development costs.

When downloading data from the internet there are some issues to be aware of. These include:

- Lack of documentation i.e. metadata.
- Media/File Size – Grid/DEM's and images tend to be huge.
- Many Different Formats – ArcInfo, MapInfo, Autocad, etc.

- Accuracy/Scale – Is it really accurate for your needs?
- Convenience – How much processing do you have to do? Would it be cheaper to purchase the data?
- Timeliness – Is the data to old to be useful?
- Coverage – Is the area you need covered by the data?
- Coordinate System – Some coordinate systems can be difficult to reproject.
- Attributes – Does the data contain the attribute information you need?
- Copyright Issues – Are there limitations as to how the data can be used?

The following are some links to potential sources of data. Most of the data on these pages are free but be aware of the data's limitations. (You get what you pay for.)

-USDA Natural Resource Conservation Service
http://www.ftw.nrcs.usda.gov/ssur_data.html
This is the official SSURGO site. All SSURGO certified soil surveys in the country can be downloaded from this site.

University of Washington libraries
http://www.lib.washington.edu/subject/WaStateMaps/dr/elnum.html

GeoDataCatalog Washington State Department of Transportation
http://www.wsdot.wa.gov/gis/geodatacatalog/
This site has a base data set for each county in the state.

Washington State Dept of Fish and Wildlife
http://www.wa.gov/wdfw/hab/release.htm/

Washington State Geospatial Clearinghouse
http://metadata.gis.washington.edu/

Washington State Department of Natural Resources
http://www.wa.gov/dnr/base/gisdata.html

Washington State Dept of Ecology
http://www.wa.gov/ecology/gis/data/data.htm

US Environmental Protection Agency
http://www.epa.gov/r10earth/datalib/

USGS EROS Home Page
http://edcwww.cr.usgs.gov/doc/edchome/ndcdb/ndcdb.html
Sources of DEM's, DOQ's, DLG's

http://www.reo.gov/reo/
A very good source for DRG's, DEM,s, and NRCS soils data.

Help in ArcView and on the Internet

Remember the ArcView "Help" menu has a glossary, and explanations of how to use all the functions of the program. Go here first. If you don't find your answer, there is a tremendous amount of information on the web about GIS. You can probably find an answer to the most arcane and obscure GIS question you can think of. If you are interested in arcane and obscure but many times useful information you can subscribe to a List. A very good one is: Arcview@lists.directionsmag.com. This list deals exclusively with questions about ArcView.

There is also a list you can subscribe to on the ESRI web page http://support.esri.com/. This site also has a searchable archive of previous questions that can be very helpful.

http://www.gfi-gis.de/en/services/avkb/ This site, based in Germany has a searchable ArcView Knowledge Base.

http://gis.esri.com/arcscripts/scripts.cfm ESRI scripts and extensions page
This is the first place to go if you are looking for scripts and extensions.

http://www.commenspace.org There are some useful scripts and extensions here categorized by use and linked to ESRI scripts.

http://www.geocomm.com/ GIS information and links.

www.gisportal.com/ GIS links.

www.esri.com/library Educational materials on GIS

www.usgs.gov/research/gis/title.html USGS GIS projects.

www.gislinx.com/ GIS Links.

www.utexas.edu/depts/grg/gcraft/contents.html The Geographer's Craft project. This excellent site has some very useful GIS educational materials.

www.geoplace.com Web site for publications dealing with GIS

gis.about.com General information about GIS.

www.gisdatadepot.com GIS information and links (do search for ArcView scripts). You specify if you want to search their site or all other applicable sites.

1.1 Downloading Data off the Internet

In the following exercises you will become familiar with getting data from the Fish & Wildlife "Streamnet" web site, Changing the projection of a different data set using the ArcView Projection Utility, and analyzing the results.

EXERCISE 1 Downloading USFW Streamnet Data

1. Downloading GIS Data From the Internet

The Streamnet web site has many different salmon related data in tabular and gis format. Be aware though of the age and accuracy of the data. You can find this out in the metadata which you should always get with any new data.

Go to the Streamnet website at www.streamnet.org . Click Online Data. Go to the bottom of the page and click GIS Layers. You should then see the following page (Figure 1.1).

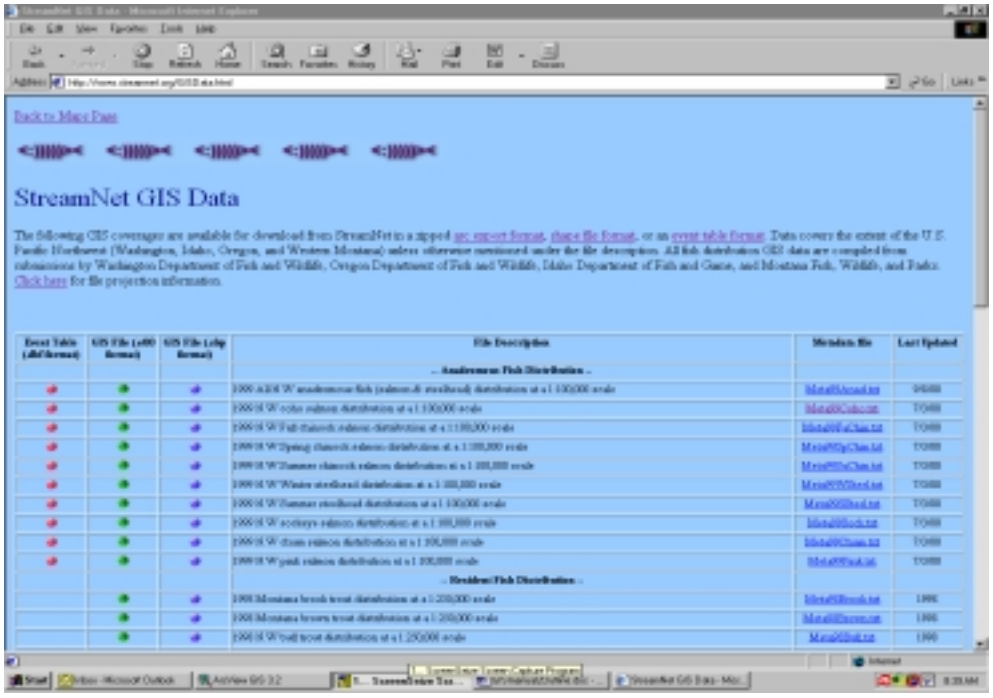

Figure 1.1

Go to your Windows Explorer *C:\GIS Data* and create a folder for the data that you are about to download. Call it "StreamNetData".

You are interested in downloading the current NW coho salmon distribution at a 1:100,000 scale in the e00 format. You also want to download the Metadata file.

Note: Remember to always get metadata when you download or receive any kind of GIS data. Without it you won't know what projection or datum it is in, what those acronyms or field names mean, the date of the data or who to contact if you have questions..

Click to download theses files. When prompted for a location to save the data, navigate to the <StreamNetData> folder you just created and save it there.

The files are in a zipped format. You need to unzip them with the WinZip utility which is a free program that you can download from the internet if you do not have it.

Open Windows Explorer and double click on the name "99cohodist.zip". When the file is unzipped you will have a file called "coho99.e00".

2. Using Import71 to Convert ArcInfo Export Files (e00)

Go to the "Start" menu, click **Programs - ESRI - ArcView - Import71** (Figure 1.2)

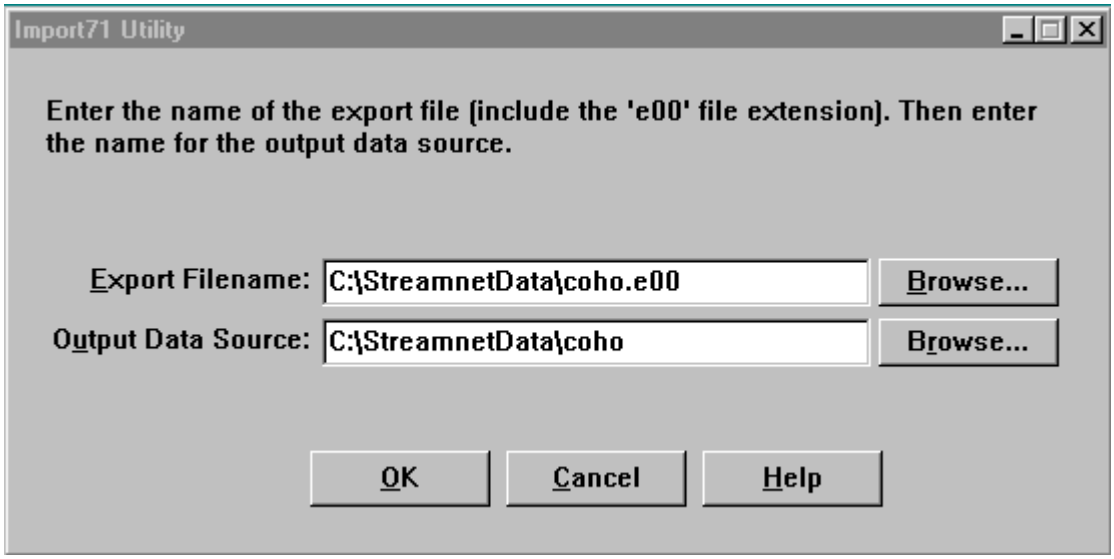

Figure 1.2

For the **Export Filename:** Click "Browse" to navigate to the folder where the "coho.e00" file is. Do the same thing with the **Output Data Source:.** Name the file "coho". It is not necessary to add a file extension. Import71 will do this. Click "OK".

Now you can add this theme into ArcView. Note that it is not a shapefile yet (even though you can see it). It will need to be converted to a shapefile before you can edit or change it's attributes.

1.3 Changing Projections of Data

EXERCISE 2 Using the Projection Utility

With the Projection Utility in ArcView you can reproject your data to make it usable with other data from outside sources that may not be in the same projection as the data you are currently using. To use this utility you must know the projection, datum and map units of the new data you are attempting to reproject and the projection, datum and map units of your existing data. Without this information you are lost. For Arc/Info coverages, information about a projection can usually be found in the **prj.adf** file under the coverage subdirectory. You can view this file with a text editor such as Notepad or WordPad. Other places to get projection information are metadata files or readme.txt files that you should have acquired with the data set.

Note: Use the Projection Utility to reproject data. Do not use the View-Properties dialog box in ArcView. This only works with data that are in decimal degrees and the reprojection is only temporary in the View.

Note: Sometimes you may get data that is in a custom projection with latitude/longitude information that is in degrees and minutes. The Projection Utility requires information in decimal degrees. Recalculate degree minutes into decimal degrees before you start. E.G., 27 degrees, 25minutes = 27 degrees, 25/60 minutes = 27.41667 decimal degrees.

1. Reprojecting Data Using the ArcView Projection Utility

In this exercise you will be projecting some clipped road data from State Plane to UTM which stands for Universal Transverse Mercator. This is the projection that most federal agencies use including the NRCS and USGS. Most of the Digital Elevation Models you download from the USGS to use with the Spatial Analyst will be in UTM.

A. Open a new project in Arc View

B. Open 2 new views – Call one **State Plane** – Call the other **UTM**. Set the properties for the State Plane view to: Map Units = feet, Measurement Units = feet. Set the view properties in the UTM view to Map Units = meters, Measurement units = feet

C. Set the working directory to **GIStemp**.

D. Add the following themes to the **State Plane** View:

Rainierroads.shp
Border.shp

E. Add the following themes to the **UTM** view:

Quadindex.shp
Borderutm.shp

The data for this project is located in the **reprojection** folder of the data CD.

F. Make the State Plane View active and make Rainier Roads the active Theme.

G. Go to **File – Extensions** and scroll down until you see "Projection Utility Wizard". Click on the check box to the left of it and click OK. This will load the Projection Utility Wizard. Before you load the Projection Utility remember to make the Theme you want to reproject the active Theme.

H. Go to **File – ArcView Projection Utility**. The extension will take a few seconds to load.

Note: It is a good idea to only load extensions when you need them. They take up extra memory and could cause complications with dependencies in your project if you save it with extensions loaded.

After the Projection Utility Wizard starts you will see the first dialog box of the Wizard. (Figure 1.3)

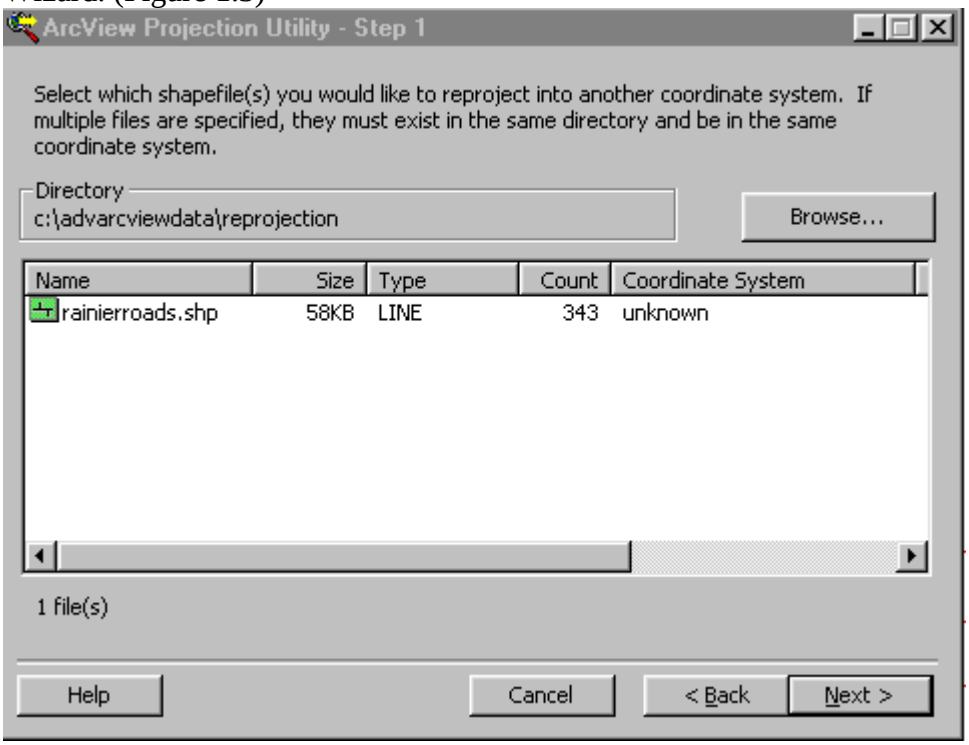

Figure 1.3

I. Click next. Step 2 of the Projection Utility Wizard asks you what projection the current shapefile is in. Our data is Projected in **NAD_1983_ Washington_South[32149].** The units are: **Foot[9002]**

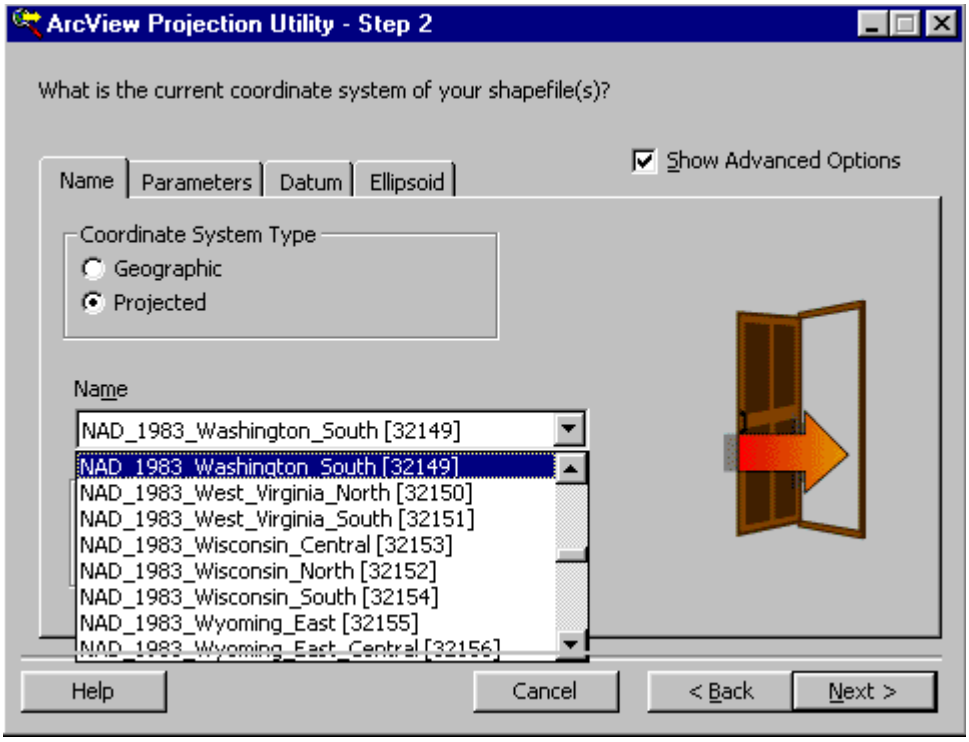

Figure 1.4

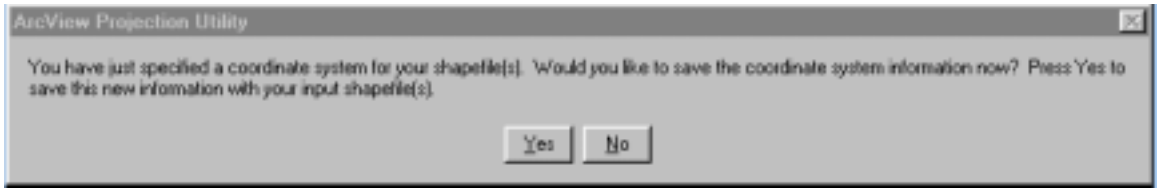

Figure 1.5

When prompted, click "Yes" to saving the coordinate system with the shapefile.

Note: You would want to choose "No" to saving the coordinate system with the shapefile if you are not sure about your parameters. If you click yes that coordinate system is linked to the shapefile with a .prj file.

J. Step 3 of the Projection Utility asks what the new coordinate system will be. Choose **NAD_1927_UTM_Zone10N[26710**]. The units will be **meters**.

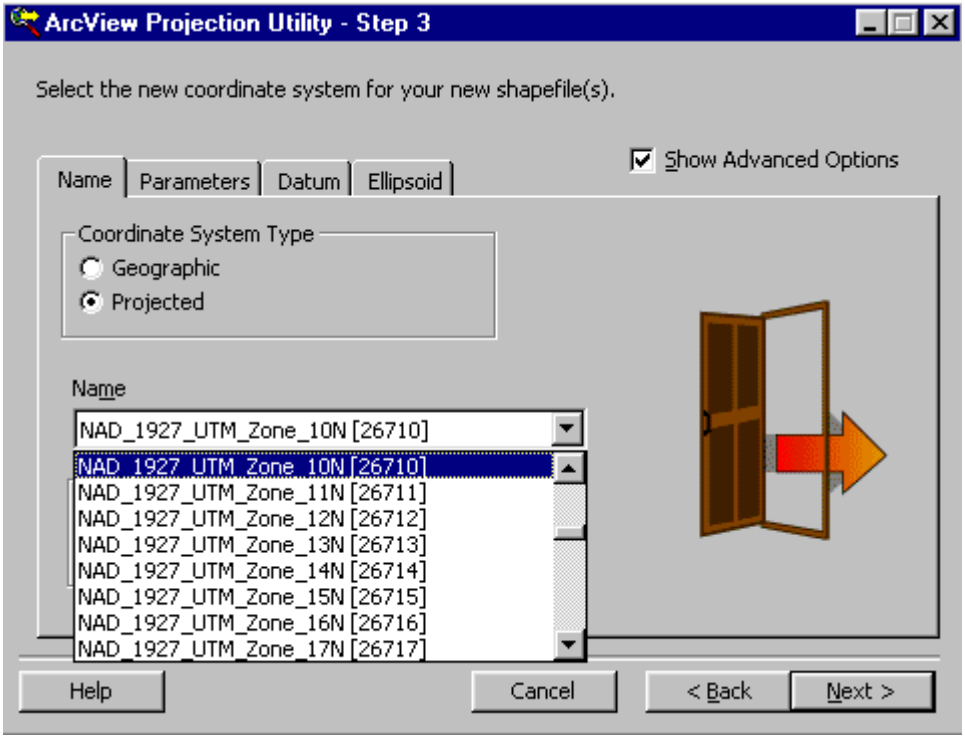

Figure 1.6

K. Click on the **Datum** Tab for step 3. Choose **WGS_1984_6_to_NAD_1927** (Figure 1.7) Click next.

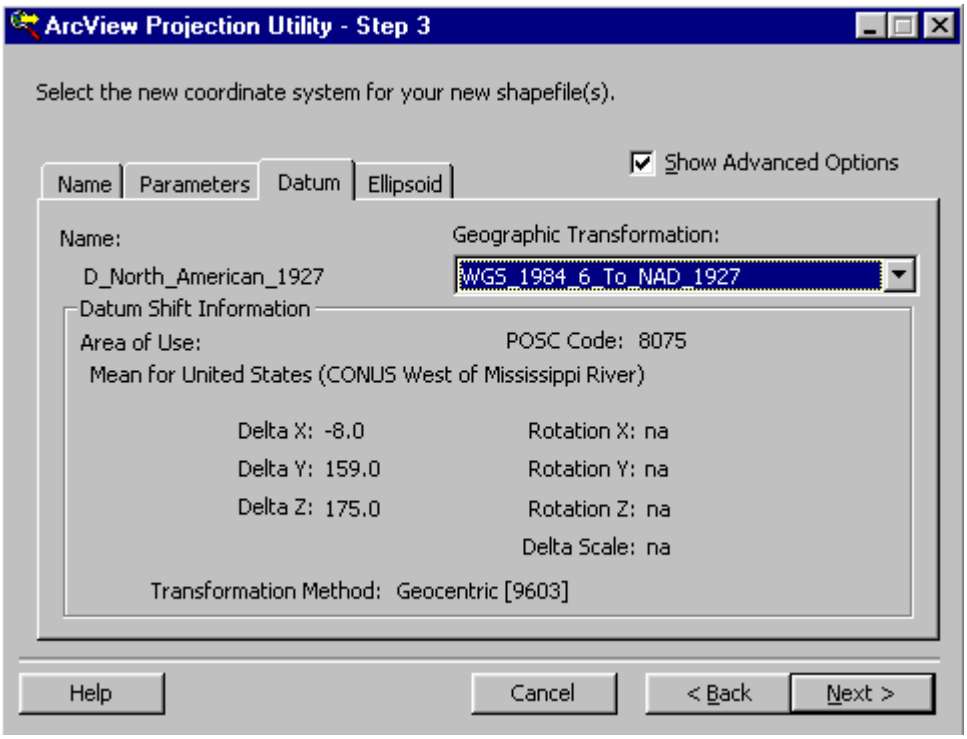

Figure 1.7

L. Step 4 asks you where you would like to store the reprojected data. Save it in **c:\gistemp** and call the shapefile **rainierepro.shp**.

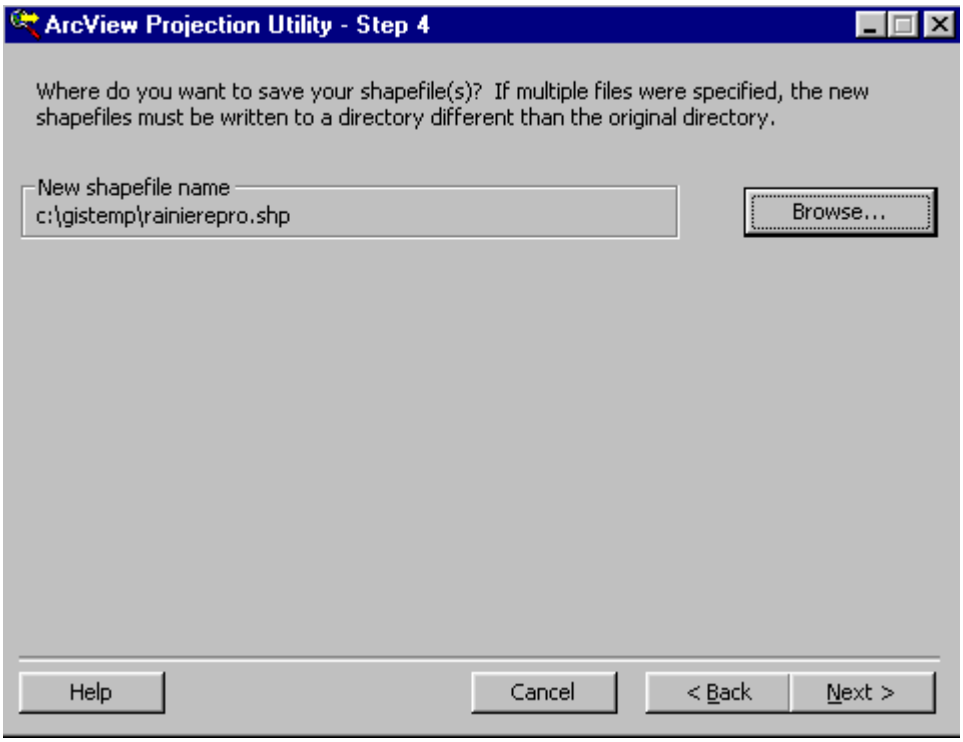

Figure 1.8

M. The final step of the process is to review your settings in the Summary window. If everything looks correct click on **Finish**.

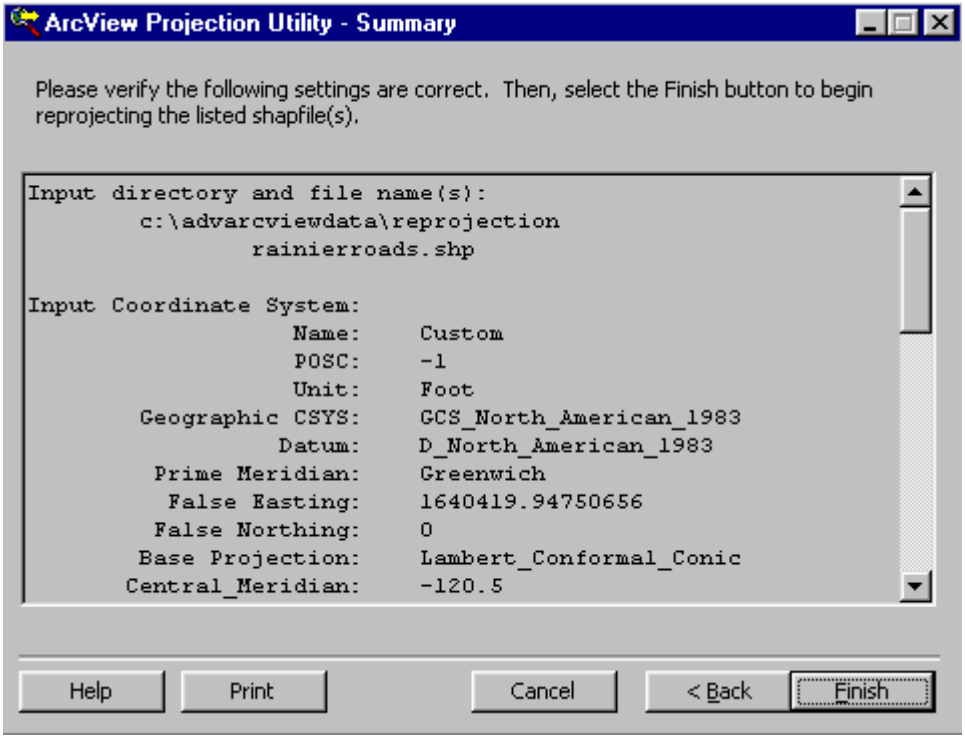

Figure 1.9

N. When the process is complete you will be asked if you want to add the shapefile to your view. Choose yes and navigate to the **gistemp** folder (your working directory) and add the **rainierepro** theme to the UTM view.

   Your reprojected theme should look like Figure 1.10.

For extra credit you can reproject the file back to State Plane.

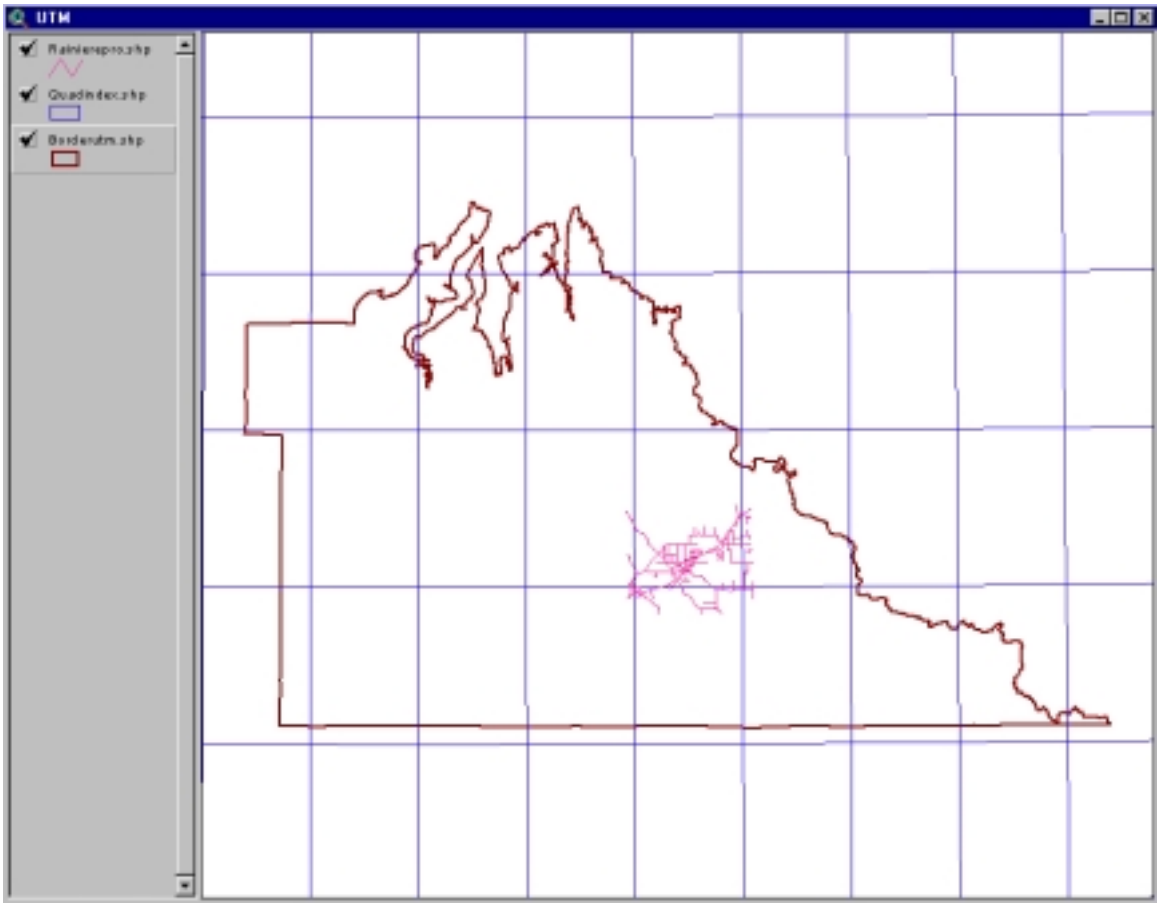

Figure 1.10

O. Close the project in Arc View.

2.0 Working With Tables In and Out of ArcView

What you will learn:

- How to export Arc View tables (.dbf)
- How to save .dbf files in Excel
- How to create .dbf files in Excel
- How to connect ArcView to an Access database using ODBC and SQL Connect
- How to create an Event Theme, reproject it, link with another table and modify the data with the Field Calculator
- How to use the Field Calculator to create a labeling field
- How to modify a table to use Hot Links in ArcView

One of the most powerful features of ArcView is its ability to use database tables and attach attributes to spatial features. This is where the usefulness of GIS really comes out. However, learning to manipulate your data in ArcView can be a steep learning curve. This section will try to make that curve a little less steep and, perhaps, provide a handrail.

Much of the following information has been taken from **The School of Architecture at UT Austin** ArcView Tips page. We would like to thank Barbara Parameter from the University of Texas at Austin School of Architecture her graciousness in letting us use this material.

To export data from ArcView to a spreadsheet or database program:

If your attribute data is already in dBase format (e.g., for a parcel shapefile, you have a parcel.dbf file), you can bring that file directly up in most spreadsheet and database programs by selecting view all files in the folder.

Saving database files in Excel:

ArcView uses dBase files directly without any special import. Most spreadsheet and database programs can save files in dBase format (usually you choose File-Save, then choose dBase (.dbf) as the format. If given a choice, choose dBaseIV. Before doing this, make sure your field names are dBase compliant: 10 characters maximum in length, no spaces.

Note: the same process can be accomplished in a spreadsheet or database program - read the online help that comes with the software program you wish to use.

Using Excel to create dBase files:

1. **Reorder** the data rows if necessary so that the first one has valid, non-blank values in all fields. If there is no such record, create a "fake" first record and fill it with valid non-blank values. You can delete it after the conversion has occurred.

2. **Format** each numeric and date column explicitly. Make sure the entire column is formatted, not just part of it. Specify the number of decimal places you want.

3. **Widen** all columns to contain all the data in them. One way is to increase the font to 14 points and auto-size all columns. This seems to work well. You can increase column widths beyond this minimum to accommodate future values that might be even longer in width.

4. **Type** short meaningful **field names** in the *single* header row. Remember, the dBase format limits you to 10 characters.

5. **Delete any blank rows** placed in the spreadsheet merely for formatting purposes.

6. **Check** that all values in all numeric columns really are numbers. Fix any errors.

7. **Remove** any hidden rows or columns within the data.

8. **Verify** that there is no named array called "Database." If there is, remove it or set it equal to the array of data (including the header row) you want to save in dBase format.

9. **Save** the spreadsheet at this point in its *native Excel* format. This preserves everything you see, including all formatting, giving you a point you can return to if the next steps reveal errors.

10. **Convert** the spreadsheet to dBase format using Excel's save as command. dBase III or IV formats are compatible with ArcView.

11. **Close** the spreadsheet immediately. (Minimizing does not work: it has to be closed.) Now open the .dbf version you just created.

12. **Check** the results carefully. If they are unacceptable, close the .dbf version and reopen the Excel version. Fix the problem(s) and resume at step 9.

13. **Clean up**: if the results are ok, delete your initial "fake" record if you used one and re-save the file in dBase format.

The dBASE file formats DBF 2 (dBASE II), DBF 3 (dBASE III), and DBF 4 (dBASE IV) save only the text and values as they are displayed in cells of the active worksheet.

All cell formatting, page layout settings, graphics, objects, and other Microsoft Excel 97 features are lost. The data displayed in the current view of a PivotTable is saved; all other PivotTable data is lost.
All rows are saved; the following numbers of columns are saved.

- DBF 2 (dBASE II) 32
- DBF 3 (dBASE III) 128
- **DBF 4 (dBASE IV) 256** ← This is the format to use in ArcView

Text values in the first row of the range are used as dBASE field names, which are limited to 10 characters and cannot contain any spaces; subsequent characters are truncated. If the first row contains all numbers, automatic field names (N1, N2, and so on) are inserted in the converted file.

Data types of values in the first row of data in the converted range determine the data types of each field (column) of data. If the first row of data contains a blank value for a field, the field is converted as a text field, even if subsequent rows contain numbers in that field; the numbers are converted as text.

Only data visible in the worksheet cells is saved. Widen the columns in Microsoft Excel, and make sure all the data is visible before you save the sheet in dBASE format.
If cells contain decimal fractions but are formatted in Microsoft Excel with the General number format, the values are rounded to the closest whole number. To preserve numbers to the right of the decimal point, format the cells with the Number format, and then specify the number of decimal places you want saved.

If cells in the converted range contain formulas, only the resulting values of formulas are saved, even if the sheet display options are set to show formulas in the worksheet cells instead of values. To ensure that the formula values are converted correctly, click Options on the Tools menu, click the View tab, and clear the Formulas check box. Then make sure that all values are visible before you save the file. If you want to save a formula as text, insert an apostrophe (') before the formula.

Important Note - Adding new rows and columns to a previously saved dBase file in Excel

If you have used Excel to create a .dbf file, and you later want to go back and add records or columns to that .dbf file in Excel, please read the following **before you save or export the modified file**:

To add to an existing .dbf file in Excel, you must redefine the named range. This is because, unbeknownst to you, when you first exported the Excel file to a .dbf file, Excel created a "named range" for that .dbf file. If you do not modify this named range, Excel will continue using this original range and thus not include any added rows or columns

on subsequent exports to .dbf of the same file . If you don't believe me, feel free to find out the hard way by losing all your added data!

To modify the named range to **after** you have added data to an existing .dbf file and **before** you save or export the file:

1. On the **Insert** menu, point to **Name**, and then click **Define**.
2. In the **Names in workbook** box, click the name whose cell reference you want to change (this is "*database*")
3. In the **Refers to** box, change the reference (just change the last row and/or column number so that it covers all your records)
4. Choose File-Save As, and save to a new .dbf (this ensures that you don't accidentally destroy your original file without being sure this process has worked)

Linking ArcView to an MS Access Database

There are several reasons you may want to be able to keep data in a relational database program such as MS Access rather than in a GIS program. A relational database program is generally much more efficient and flexible for maintaining , modifying, and querying tabular attribute data than a GIS program. Often tabular data in a database is updated continually by the responsible organization, and you may want to link to this data. Data from a tabular relational database can be brought into ArcView (and most other GIS software programs) in at least two ways:

- Databases in .dbf format can be imported into ArcView from any source that supports the .dbf format

- Databases can be queried "live" using SQL and ODBC capabilities - this method may be preferable in situations where data is continually being updated by another department or organization.

The next exercize describes the second method: live-linking ArcView to a Microsoft Access database.

EXERCISE 1 Connect to An Access Database in Arc View Using SQL Connect

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The Basic SQL Connect Process:

Assuming you have an Access database (including tables or queries), follow these steps to connect to it from ArcView:

1. Make sure that any fields in Access (including fields in queries) which you plan to query using ArcView have dBase-compatible field names: 10

characters maximum in length, no spaces, no odd characters, etc. Also do not use hyphens! If these field names are not dBase compliant, you will get an error message when trying to connect from ArcView.

2. In the ArcView Project Menu, choose <Project> <SQL>

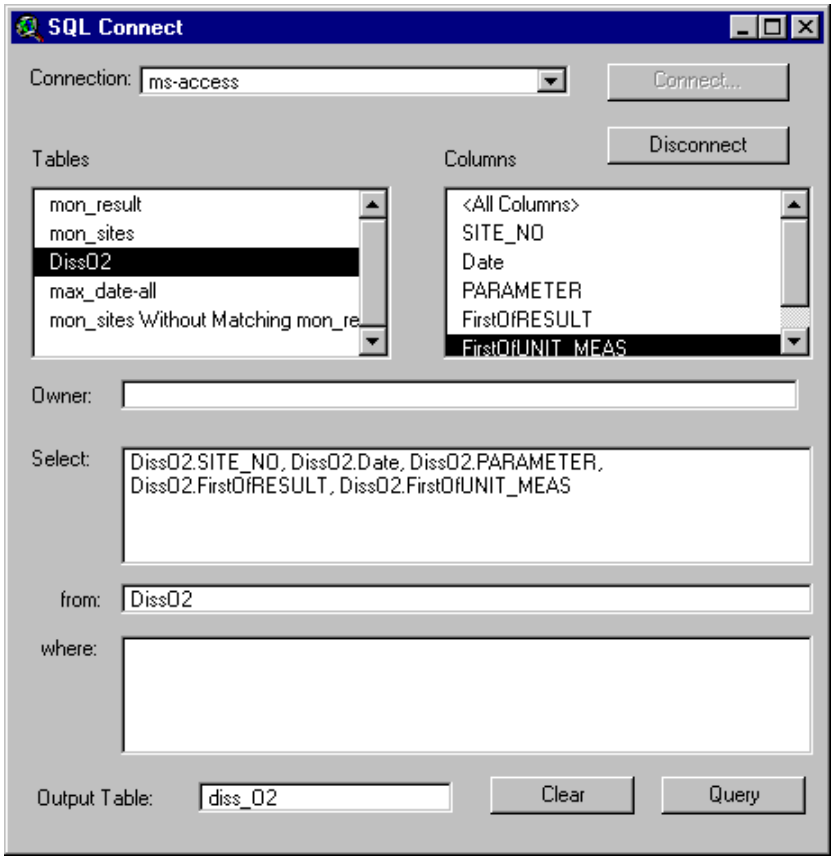


Figure 2.1

3. You are then presented with the SQL Connect form. The example form has been completely filled out to query an access database containing water (Figure 2.1).

4. In the SQL Connect dialog box, specify your "Connection" as "ms-access" (if this isn't an option, see note below on using the ODBC Manager)

5. Click on the CONNECT button

6. In the file dialog box that appears, navigate to where your Access database is stored and select that file (.mdb)

7. If the connection is made, you will see all the available tables and queries in the left hand side of the SQL Connect form.

8. Choose the table or query to which you wish to connect by clicking on its name -this places the available field list on the right side of the form

9. Choose the fields you want in your query by double-clicking on each one - this places the field name in the SELECT window of the form

10. Fill out the FROM part of the form by double-clicking on the table or query name

11. You can write criteria in the WHERE window, but it is generally easier to do this in your Access query form than here (so leave it blank)

12. Under OUTPUT TABLE, there will be a default name (e.g., table1) - you can change this to whatever you wish; the name you specify here will be the table's name once it is brought into ArcView

13. Click on QUERY to run the query - if all goes well, the new table should appear in ArcView. If it shares a field with a Theme's attribute table, then it can be joined to that table and data from Access can be displayed on the map.

Using the ODBC Manager to Configure a Connection

ODBC stands for Open Database Connectivity, and the ODBC Manager in Windows NT, 2000 etc. manages how different databases, including Excel, Access, Arcview, etc., can link to one another. Before any link is made, a connection must be established by using the ODBC Manager. Because others may have used and established these connections already, you generally will not have to do this yourself. However, if you do not find an existing Access connection from ArcView, you will have to use the ODBC Manager to establish one. The following steps tell you how to do this

Note: These instructions assume that MS-Access SQL driver has been installed with Microsoft Access - this is only done by doing the CUSTOM installation of Microsoft Access or Microsoft Office; a "typical" installation does not install these drivers.

1. Click on the Windows START button, then go to SETTINGS - CONTROL PANEL

2. In the CONTROL PANEL window, double click on the ODBC icon.

3. You will see the following dialog (Figure 2.2).

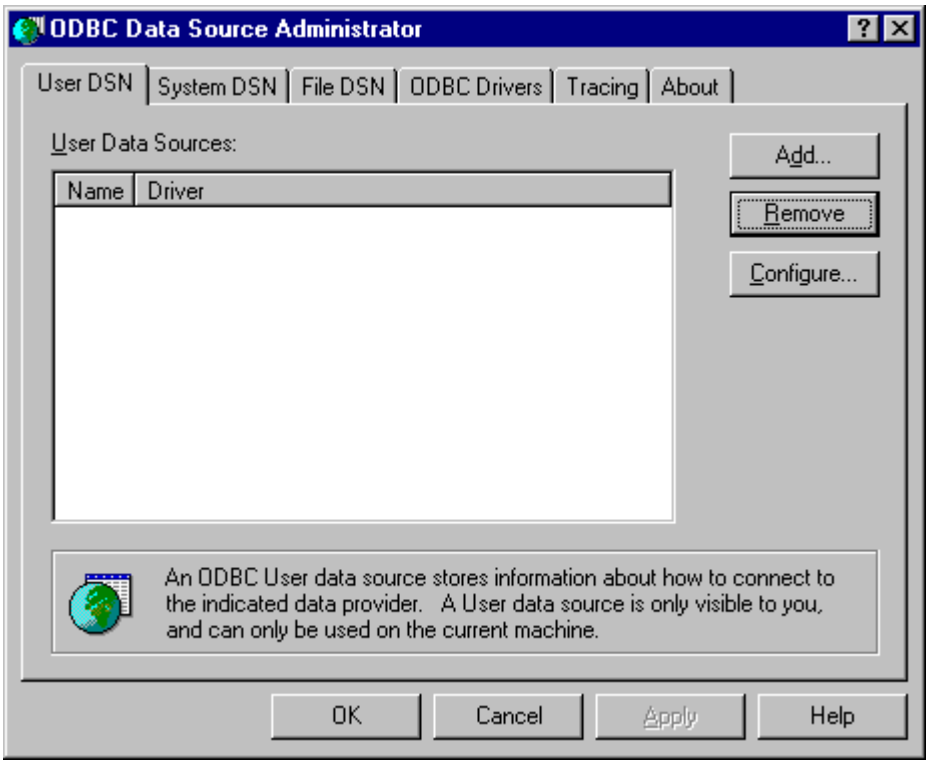


Figure 2.2

4. Under the User DSN tab, click Add.

5. Select the Microsoft Access Driver and click Finish.

6. For Data Source Name, type “ms-access”

7. Choose OK. The "ms-access" driver should now appear under User Data Sources

8. Click OK to exit

9. Close the CONTROL PANEL

Note: Important If you go through this process in the middle of an ArcView session, ArcView will not "see" the new connection options in the SQL Connect form - you must exit out of ArcView and open it again for the new connection to be visible.

2.1 Event Themes

Event Themes enable you to map data that contains geographic locations that are not in a spatial data format, but a tabular format (.dbf or dBASE).

You can add tabular data into ArcView and create a point Theme if the table contains geographic coordinates such as XY event tables (latitude/longitude). The x and y coordinates must be in separate fields in the database, but the fields can have any name. It can be in an Excel or Access format.

EXERCISE 2 Creating an Event Theme and Joining it to an Excel Field Data Table

The tables for this exercise represent GPS data collected by the Thurston Conservation District for a habitat study in the McLane Creek watershed. The location data was collected using a Trimble Geo Explorer GPS unit and Pathfinder Office software. The location coordinates were saved in decimal degrees saved in an Excel format (.xls).

1. Convert .xls to .dbf format

A. Open the "rp.xls" in Excel. Save as *File Type* DBF4 (dBASE IV) (for more information on accepted file formats refer to page 2-17). and name it "rp.dbf".

B. Open a new project in ArcView and name it "project2.apr". In the Project window, click on "Tables" and "Add" "rp.dbf".

C. Create a new View (keeping the table open). Go to View menu, "Add Event Theme". Select the table "rp.dbf" and choose the appropriate fields for the X and Y coordinates . Click "OK". The points should now be visible in your view when you turn the Theme on. Notice that the Theme name does not show the .shp extension. You need to convert it to a shapefile to reproject it or edit it. Go to *Theme – Convert to Shapefile* and save the file in your working directory.

Note: Your lat/long data might need some pretreatment. It might be a good idea, for example, to convert the lat/long values to decimal degrees. (degrees + (min/60) + (sec/3600). This data conversion can be done easily in excel (or the spreadsheet of your choice) or in ArcView by adding columns to the table and using the field calculator to populate them".

2. Reproject from Decimal Degrees to State Plane

A. Because the GPS data was saved in Decimal Degrees it will not line up with your other data which is in WA State Plane South. To remedy this go to *File – Extensions* and load the Projection Utility Wizard. Make sure your new shapefile is active and go to *File – Arc View Projection Utility.*

B. Enter the following in the first dialog of the Projection Utility for the Current Coordinate System:

Projection Type is:	***Geographic***
Coordinate System is:	***GCS_WGS_1984[4326]***
Units are:	***Degree[9102]***

Go to the Datum tab and enter the following for the Geographic Transformation:

WGS_1984_1_to_NAD_1983

C. Enter the following in the second dialog of the Projection Utility for the New Coordinate System:

Projection Type is:	***Geographic***
Coordinate System is:	***NAD_83_Washington_South[32149]***
Units are:	***Foot[9002]***

D. Rename the file to rprepro.shp and save it in your working directory. Add the Theme to your view. Add all of the Themes for McLane Creek and look at how the points line up along the stream. Having a shapefile of the points themselves with no attribute data is not very useful. Now you need to join the field data.

3. Export the Field Data From Excel

A. Open Excel and open the RP-Data.xls file. Save it as RP_sample.xls. Remove the split screen and follow the following instructions:

Using Excel to create dBase files:

- **Reorder** the data rows if necessary so that the first one has valid, non-blank values in all fields. If there is no such record, create a "fake" first record and fill it with valid non-blank values. You can delete it after the conversion has occurred.

- **Delete** the title or first two rows of the table because they won't transfer correctly to .dbf.

- **Widen** all columns to contain all the data in them. One way is to increase the font to 14 points and auto-size all columns. This seems to work well. You can increase column widths beyond this minimum to accommodate future values that might be even longer in width.

- **Type** short meaningful **field names** in the *single* header row. Remember, the dBase format limits you to 10 characters.

- **Delete any blank rows** placed in the spreadsheet merely for formatting purposes.

- **Check** that all values in all numeric columns really are numbers. Fix any errors. (skip this step)

- **Remove** any hidden rows or columns within the data.

- **Verify** that there is no named array called "Database." If there is, remove it or set it equal to the array of data (including the header row) you want to save in dBase format.

- **Save** the spreadsheet at this point in its *native Excel* format. This preserves everything you see, including all formatting, giving you a point you can return to if the next steps reveal errors.

- **Convert** the spreadsheet to dBase format using Excel's save as command. (Be sure that at least one cell is selected or you will be asked to save again). dBase III or IV formats are compatible with ArcView, but IV is most common. Keep the same file name, but with .dbf extension.

  Note: 2 message boxes will come up saying the format has changed. Click OK. You can reformat if you need to in ArcView.

- **Close** the spreadsheet immediately. (Minimizing does not work: it has to be closed.) Now open the .dbf version you just created.

- **Check** the results carefully. If they are unacceptable, close the .dbf version and reopen the Excel version. Fix the problem(s) and resume at step 9.

- **Clean up**: if the results are ok, delete your initial "fake" record if you used one and re-save the file in dBase format.

4. Join the RP-Data Theme with the Reprojected RP Theme

A. Open Arc View and go to Tables – Add. Add the new dbf table.

B. In order to link the two tables they need to have a common field. As you can see the Segment ID and the Sub-Segment ID Field are separate fields. In the RP point theme that you just reprojected the segment and sub-segment ID is in one field. What you need to do is combine the values of these two fields in "rp_data" to create a common field that can be linked.

C. Start editing the field. Go to Edit – Add Field. Add a field with the following parameters:

Name: ***Segment2***
Type: ***String***
Width: ***2***

Remember to stop editing and save edits.

Note: The .AsString and .AsNumber request are used when you are copying data from one format to another (string or number field).

D. Join the tables. Open the view with the RP points and open its attribute table. Tile the windows and make the Segment2 field active on the "RP_Sample" table and the Segment# field on the "RP.dbf" table in that order. Now look at the join table field. It should be activated If not it is because the RP_sample table is in edit mode. Click the join button and examine the resulting table. You now have the field data attached to the rp point theme. Try querying some of the data using the query expressions from the Arc View help file.

2.2 Hot Linking

Hot links are useful for viewing any files that are directly linked to a feature in the View. The files can be pictures, graphs, layouts, database, or other information
For example, you could set up the hot link, click on a feature such as a crop, and see a picture of that crop and the monitoring instrument in that field.

Here are some other ideas for types of Conservation District related hot links that can be created in ArcView:

- Revegetation sites with links to before–and-after digital photos
- CAD drawings of stream engineering projects
- Stream reaches with links to spreadsheets of water quality data
- District map with links to farm plan summaries
- Watershed map with links to CREP participant data
- Dairy map with links to manure brokering data

EXERCISE 2 Hot Linking

In this exercise you will learn to create a point theme with hot links to sample image files (gif and tif format).

1. Make a new View in "project2.apr"

Go to **View – Properties** and set the Map Units and Distance Units to "feet". Call the View "2000 District Projects". Name the Theme "2000 District Projects.

2. Add the following Themes:

- basins.shp
- lakes.shp
- projects.shp
- culverts.shp
- streams. shp

Make these Themes visible. Arrange the Themes so that the line and point Themes are on top of the polygon Themes. The basins Theme should be on the bottom.

Note: JPEG format images will not work for hot linking in Arc View. Most image editing software will let you change the format of images to tiff , giff or bmp.

A. Open the Table and Start Editing.
B. Add the following fields:

Prj_nm
Prj_type
Image

For **Type:** use "String". For **Width** use "20" as shown in Figure 2.3.

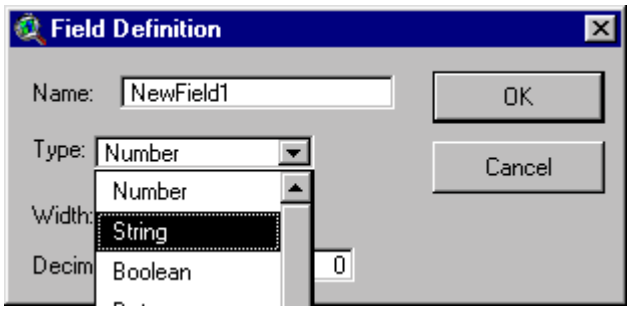
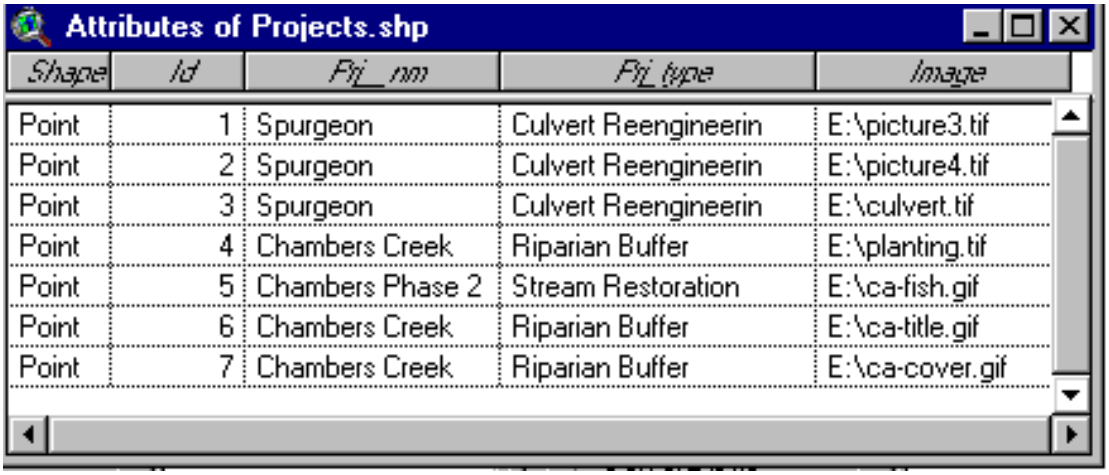


Figure 2.3

After you have created the fields, you are ready to populate your table with data.

4. Add the data in Figure 2.4 using the Edit Tool



Shape	Id	Prj_nm	Prj_type	Image
Point	1	Spurgeon	Culvert Reengineerin	E:\picture3.tif
Point	2	Spurgeon	Culvert Reengineerin	E:\picture4.tif
Point	3	Spurgeon	Culvert Reengineerin	E:\culvert.tif
Point	4	Chambers Creek	Riparian Buffer	E:\planting.tif
Point	5	Chambers Phase 2	Stream Restoration	E:\ca-fish.gif
Point	6	Chambers Creek	Riparian Buffer	E:\ca-title.gif
Point	7	Chambers Creek	Riparian Buffer	E:\ca-cover.gif

Figure 2.4

5. When you are finished adding data go to Table - Stop Editing and save edits.

The image field contains the directory information that will be used for hot linking. This field must contain the directory path where the data you want to link to is located.

> **Note:** you may have to change the directory path location if your image files are located in a different drive or directory location.

7. Enable the Hot Links Tool

A. Go to **Theme - Properties**. Scroll down the left hand side of the dialog box and choose "Hot Link" icon. For "Field" choose "Image". For "Predefined Action" choose "Link to Image File" (Figure 2.5).

B. Enable Hot Linking in the Projects.shp Theme by choosing "image" as the Field and "Link to Image File" as the Predefined Action.

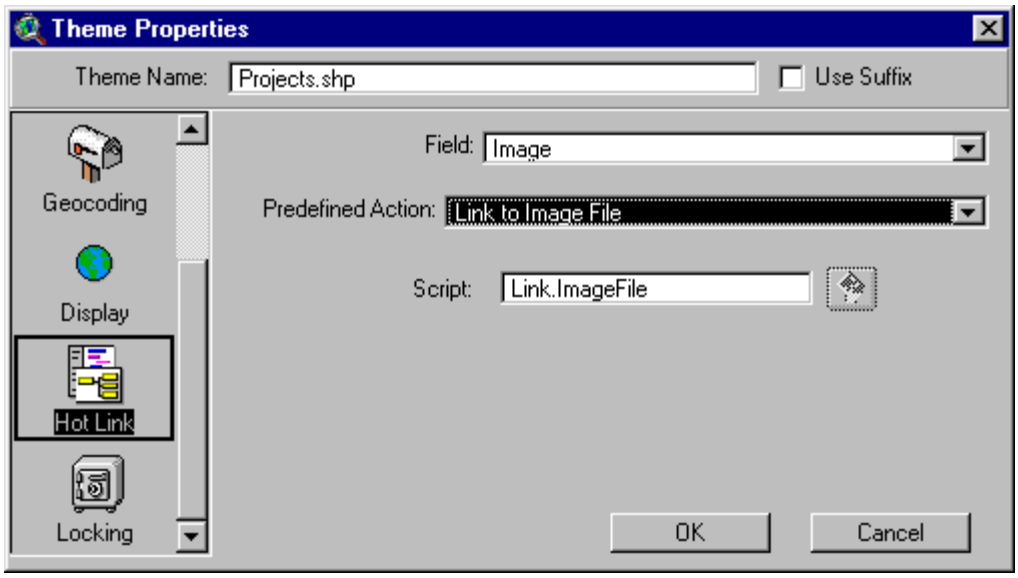


Figure 2.5

C. Click OK. Now when you go to the "2000 District Projects" View and make the Projects.shp Theme active you will see that the Hot Link Tool has been enabled.

D. Select the **Hot Link** tool and click over a feature in the active Theme.

   The associated image should be visible in a pop up box. The image may take several seconds to load depending on your system. If some of the links are not working check the drive and directory path in the image table.

E. Save the Project.

2.3 Labeling With Multiple Fields Using the Field Calculator

The Field Calculator can be used for many operations in tables in ArcView. You can create a field for labeling, concatenate or combine the values in two fields, set the number of decimal places to display in a field, extract values from a field, convert meter values in one field to feet plus many more operations.

The Field calculator uses Avenue expressions so it is a good way to get started with understanding the Avenue programming language in ArcView.

EXERCISE 3 Using the Field Calculator to Create Better Labels

In this exercise you will learn to use many different expressions to create a new label field in a shapefile that contains farm plan data.

1. Label multiple strings of information

A. Open a new Project in ArcView and open a new View.

B. Go to **View – Properties** and set the Map Units and Distance Units to "feet".

C. Go to **File – Set Working Directory** and set the working directory to **gistemp**.

D. Add the **eldfarmplans.shp** Theme to the View (This Theme is located in the Henderson folder of the Advanced ArcView data.

E. Open the Attribute table for Eldfarmplans.shp.

F. Go to **Table – Start Editing** then go to **Edit – Add Field**.

G. Add a new field called "Labels". Make the Type "String" and the Width "80" (figure 2.6).

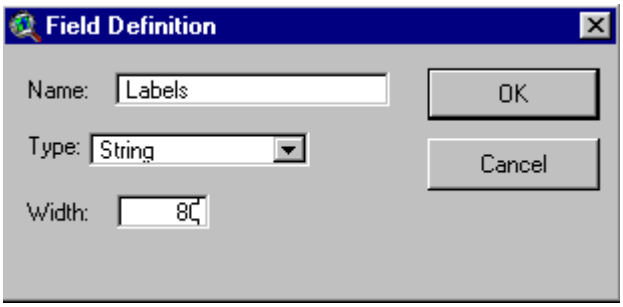


Figure 2.6

H. Click on the **Field Calculator Button**. 

The field calculator dialog box will appear (figure 2.7).

I. Fill in the expression below **exactly**. Remember to double click on the field names and requests. If you scroll down the requests list you will find the **SetFormat** and **AsString** requests but you will not find NL. It is very likely that you will get a syntax error the first or second time you try this. Be patient and remember to double click whenever you can and pay attention to spaces.

[Owner_name] + NL + "Parcel #" + [Parcel_no] + NL+ "Date Approved:" ++ [Date] + NL + [Acres].SetFormat("d.d").AsString ++ "acres"

What this expression says in plain English is:

> Add the Owner_name field, add a new line and add the text Parcel# and the field Parcel Number, add a new line and add the text Date Approved with a space and add the Date field , add a new line and add the Acres field and set the format to one decimal place and change it to a text string and add the text acres with a space.

- **NL** means add a new line
- ++ Concatenates 2 strings and inserts a space between them
- **"a string"** Anything between quotations means string characters
- **.SetFormat** designates the number of decimal places displayed
- **.AsString** changes the values in a field from a number to a string

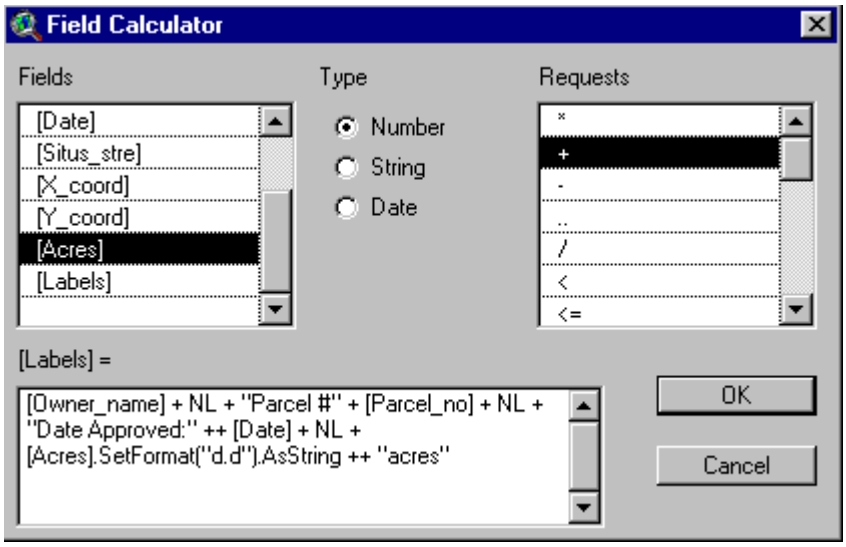


Figure 2.7

J. If you are successful go to **Table – Stop Editing** click yes to save edits.

K. Go to **Theme Properties** and click on the Text Labels tab and change the label Field to **Labels** (figure 2.8).

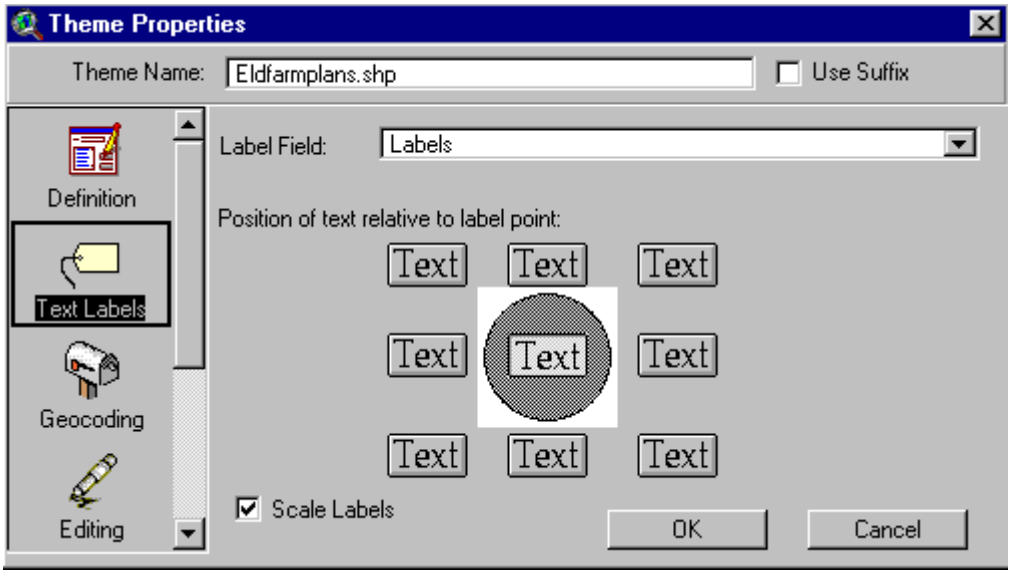


Figure 2.8

Try labeling some or all of the parcels. You will be able to use any of the label tools to label your parcels (Figure 2.9).

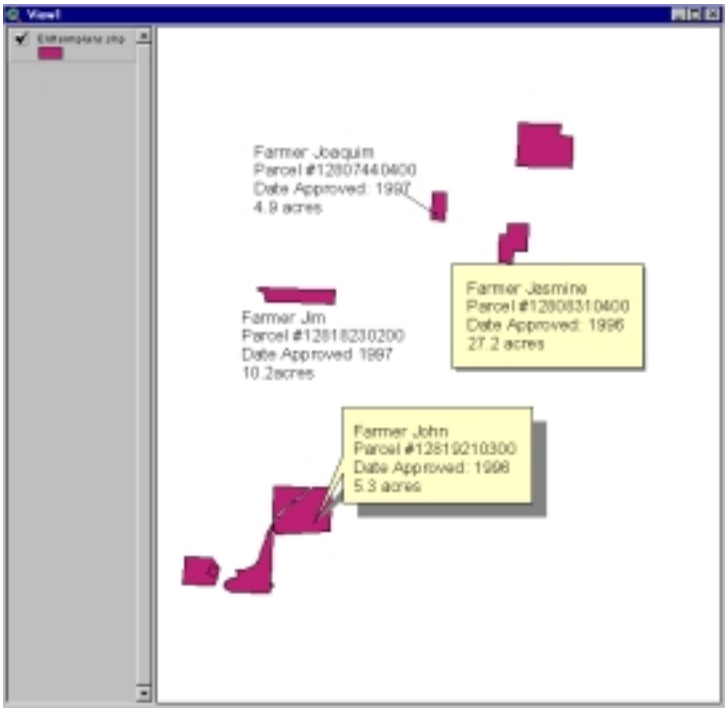


Figure 2.9

L. Close the project without saving.

3.0 Project Data Management & Arc View Customization

What you will learn:

- File and Data Management
- Project Repair and Portability
- Metadata
- Adding Scripts and Extensions To Arc View
- GUI Customization

In ArcView there are right ways and wrong ways to manage projects, shapefiles and extensions. The following exercises and materials will provide better management tools of your GIS data.

Understanding what shapefiles are:

The shapefile format defines the geometry and attributes of geographically-referenced features in as many as five files with specific file extensions that should be stored in the same project workspace. They are:

1. **.shp** - the file that stores the feature geometry.

2. **.shx** - the file that stores the index of the feature geometry.

3. **.dbf** - the dBASE file that stores the attribute information of features. When a shapefile is added as a theme to a view, this file is displayed as a feature table.

4. **.sbn and .sbx** - the files that store the spatial index of the features. These two files may not exist until you perform theme on theme selection, spatial join, or create an index on a theme's Shape field. If you have write access to the source data directory, the index files will be persistent and remain after your ArcView session is complete. If you do not have write access to the source data directory, they will be removed when you close the project or exit ArcView.

5. **.ain and .aih** - the files that store the attribute index of the active fields in a table or a theme's attribute table. These two files may not exist until you perform Link on the tables. If you have write access to the source data directory, the index files will be persistent and remain after your ArcView session is complete. If you do not have write access to the source data directory, they will be removed when you close the project or exit ArcView.

EXERCISE 1 File Management and Project Repair

Go to Windows Explorer and open the file *C:\temp\data*. Notice the shapefiles and their associated files. Each Theme is composed of at least three files. These files must always stay together. If they are split into different locations, then you will not be able to see them in ArcView and you will get an error. If these files are separated or moved improperly when you are in ArcView, you may get a similar error or you may lose access to that project. To properly move, delete, or rename a shapefile follow these steps:

1. Copy, Delete, and Rename a shapefile using "Managing Data Sources"

A. Open a new Project and a new View. Don't name the Project or View. "project Go to File menu and click "Manage Data Sources". Move a file (choose one and put it in a different directory). Now Delete a file and Rename a file.

B. Open up Explorer or My Computer to check for your changes.

Note: You must not have any shapefiles or "Attributes of shapefiles" open when performing these functions. This procedure does not work for image files or graphics.

Occasionally a function you are performing in ArcView can trigger a common error called a "segmentation violation". Most of the time we don't know what exactly causes the error. There are many possibilities. One of the most obvious would be if you delete a record in the actual .dbf file and it's not reflected in the "attributes of" .dbf linked to the spatial data. The result is a missing record, but the spatial feature is still in the index file.

Segmentation violation errors can be major or minor: the error can lead to a minor problem that can be fixed by not saving the last changes you made, or it can lead to a major problem where the error won't go away and you can't do anything in the Project. Here are some suggestions for dealing with this annoying situation in ArcView.

2. Repairing a Corrupt Shapefile

A. Use shapechecker. It's a stand alone program developed by an ArcView user (not ESRI). Double click *shpchk.exe* on your desktop to open it. It looks at all the files associated with the shapefile to see if the number of records in the .dbf match the number of records in the header (.shx) file. It will "fix" minor corrupted files on the fly (Figure 3.1).

B. Click "Shapefile" button and select the file chosen by the instructor "Open". Follow the instructions. If the number of records in .dbf matches the number of records in the header, then the file is fine. Close out of the program.

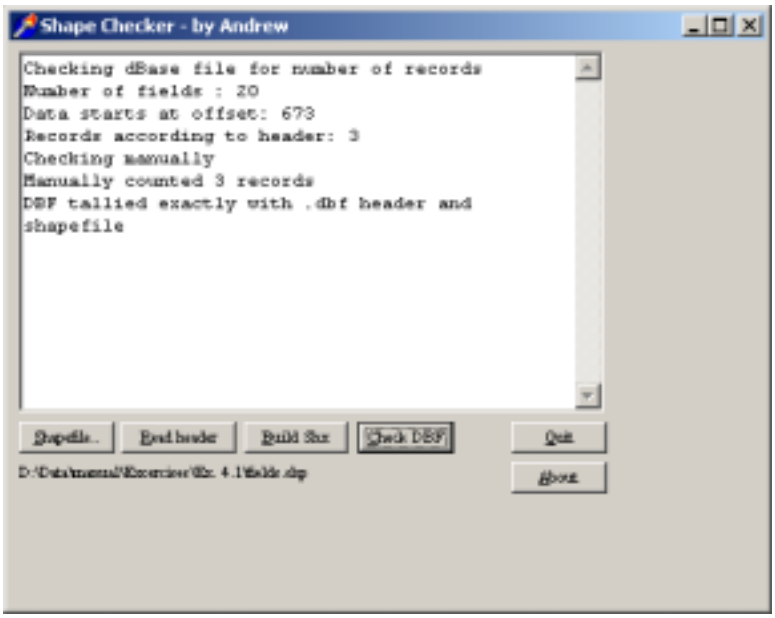


Figure 3.1

If there is still something wrong with the shapefile or your project, follow the steps "Trouble Shooting Segmentation Violations" by ESRI, in the Appendix.

Beating Segmentation Violations:

1. Every time you open a Project, save a back up before making changes.
2. Never ignore a segmentation violation! At this point, ArcView is in an unstable state and the situation could get worse. If the Project is saved, the unstable elements will be written into the .apr. The next time you open the Project, the error will appear. When you get the error, save the Project as a different name and hopefully the error won't be reflected. If it is, revert back to the old file and go through the steps in the Appendix, "Trouble Shooting Segmentation Violations".
3. Stream-line you ArcView Projects. Remove any unneeded elements from the Project: themes, tables, scripts, layouts, views, etc.
4. Turn off extensions when you are not using them.
5. Practice new operations in a new Project. Once you are convinced they are successful, then transfer it to a working Project.

What do you do if a file is deleted outside of a ArcView Project or the path name has changed? ArcView is not aware of the change until you point to the files by going through the "Where is" process (Figure 3.2).

You can go through this process, but what if there are unknown amount of files to "relocate" before you can restore your Project as it was??

Answer: AVOID THIS SITUATION ALTOGETHER!

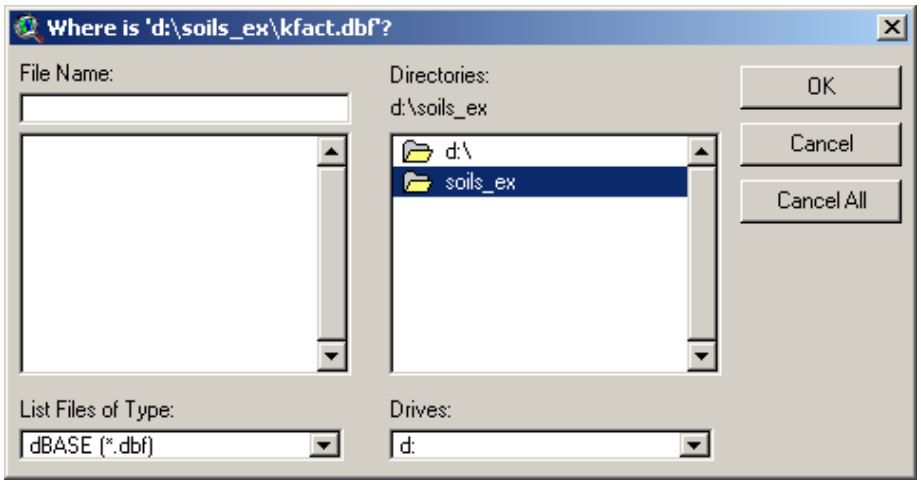


Figure 3.2

Remember to use "Manage Data Sources" to move, rename, and delete shapefiles.

Other useful tools are extensions called "avapr.avx" and "chpath.ave" The "Project File Organizer" (avapr.avx) will copy the .apr file to any new file locations and will search for all data files associated with it and copy them to the designated folder. The "Change Path" script (chpath.ave) removes any paths to the files and makes it easy to copy the project to a CD. These extensions and their variations can be found on the ESRI Arcscripts page.

3. Making Projects Portable

A. Make a new folder in C:\temp. Call it "port_proj" (Remember, NO SPACES OR PERIODS in the folder name).

B. Open the Project that you want to make portable. In this case it is "project6.apr".

C. Go to the **File** menu and click on **Extensions**. Turn on the extension called "Project File Organizer". It will add a new menu item to the ArcView's File menu. Go to **File - Transfer Project File**. Specify the new location: *C:\temp\port_proj*. Keep the name the same (you have the option of renaming it). Click OK. Once the transfer is done it will bring up a dialog box that says, "Project File Transfer Complete".

D. Close out of the Project and open it in it's new location. It should open right into the Project without the "Where is" dialog box. Close the Project.

Note: See Appendix to get instructions on how to install the "Project File Organizer" extension. This readme file comes with the download from www.esri.arcscripts To load "path stipper", simply download the .ave file in your specified location. When you want to run the script go and get it as described below.

Notes:
1. Be sure your project is free of errors or "Where is" dialog BEFORE you use this extension. If your Project is asking where files are and you click "Cancel All" then proceed to transfer that project file, you will be relocating a project that doesn't have the files in it.
2. Be sure all of the extensions that you need for that project are on at both ends (computers) or you may have problems.
3. Turn off extensions and save before you transfer the Project.
4. The extension is only available in the Project window.
5. Streamline large data sets by clipping specified area first. (It's easier and less time consuming to transfer small projects.)

4. Stripping the path names

A. Open the moved project in the *C:\temp\port_proj* folder.
B. Make a new script (Click Scripts icon in the Project window and click New).
C. Go to **Script** menu, click **Write Text File** (Figure 3.3)

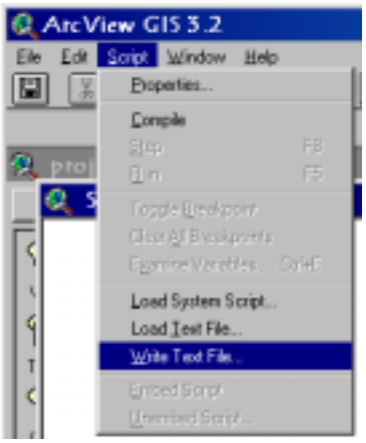


Figure 3.3

D. Go to the following directory and get "chpath.ave":
C:\temp\data\chpath.ave
The script will be in the script window (Figure 3.4)

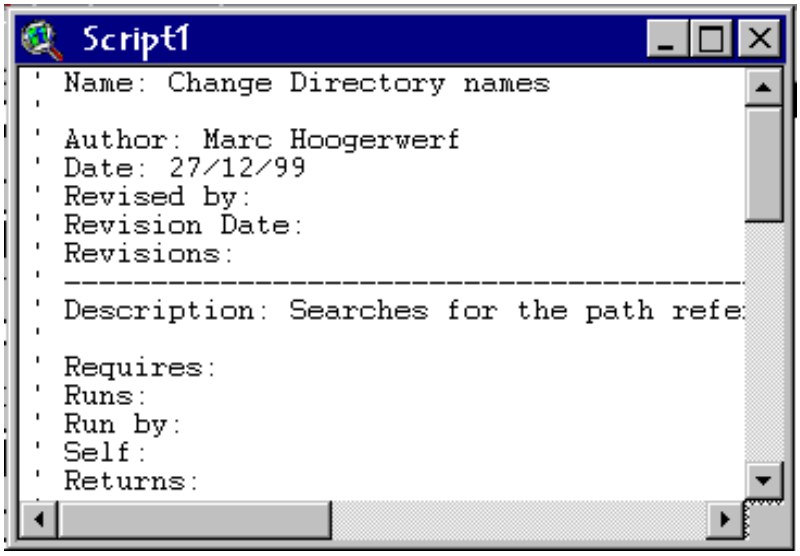


Figure 3.4

E. Click the "Compile" button. 

F. Click the "Run" button. 

G. A dialog box will come up asking you to select the Project. Go to the location of project6.apr. Click OK. The project paths have been stripped. A Project file with the name "project6**n**.apr" will be added. The stripped project will always have an "n" in the name.

Project Dependency

If an extension is turned on when a Project is saved, the Project becomes dependent on that extension. So, if anyone deletes of moves the extension, ArcView will go through Project Repair and prompt you for the location of the extension. If the extension cannot be located, the Project will not open.

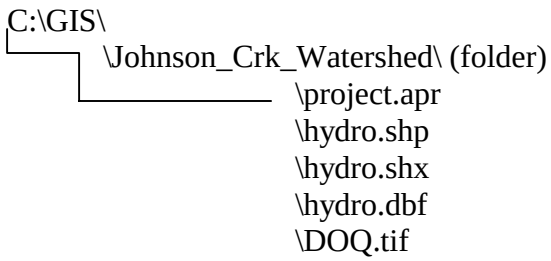
It is not a good idea to turn on all extensions because each extension may have several controls to your Project making ArcView GUIs very complicated. Also, your Project files will be significantly bigger.

What about Project file size?? The sky is NOT the limit!

Answer: Keep your .apr files small! Under 1 MB to be on the safe side. Larger .apr files are one of the most common causes of unstable or corrupt projects. Recovering them can be cumbersome and not always successful.

Naming Projects using Relative Pathnames and Directory Structure:

Name Projects according to that "Project". Put files in a subfolder of the .apr.
For example:



NOTE: RULE OF THUMB…….NEVER PUT SPACES, PERIODS, ETC. IN NAMES OF GIS FILES AND FOLDERS!! SUBSTITUTE SPACES TH UNDERSCORE (_).

3.1 Metadata

Standards for procedures and products should always be documented in writing or in the dataset itself. Data documentation should include information about how data was collected and from what sources, how it was preprocessed and geocoded, how it was entered in the dataset, and how it is classified and encoded. On larger projects, one person or a team should be assigned responsibility for data documentation. Documentation is vitally important to the value and future use of a dataset. The saying is that an undocumented dataset is a worthless dataset. By in large, this is true. Without clear documentation a dataset can not be expanded and cannot be used by other people or organizations now or in the future.

Documentation is of critical importance in large GIS projects because the dataset will almost certainly outlive the people who created it. That is, GIS for municipal, state, and AM/FM applications are usually designed to last 50-100 years. The staff who enters the data may have long retired when a question arises about the characteristics of their work. **Written documentation is essential**. Some projects actually place information about data quality and quality control directly in a GIS dataset as independent layers.

What about data from other sources?

Before you use it…ask these questions:

What is the age of the data?
Where did it come from?
In what medium was it originally produced?
What is the real coverage of the data?

To what map scale was the data digitized?
What projection, coordinate system, and datum were used in maps?
What was the density of observations used for its compilation?
How accurate are positional and attribute features?
Does the data seem logical and consistent?
Do cartographic representations look "clean?"
Is the data relevant to the project at hand?
In what format is the data kept?
How was the data checked?
Why was the data compiled?
What is the reliability of the provider?

You can use the list above to create metadata for your data. Here is a sample of a simple txt file with the necessary metadata for CDs (available in the data CD that comes with the training program) Please use this as a template for your work:

Sample Metadata Report

Metadata Report for Wa. Conservation Districts 9/00

Title: (field boundaries in Kittitas County)
Description:
Abstract: Kittitas County Field Boundaries are polygons georeferenced from FSA records.
Purpose: for tracking crop patterns, applications, irrigation methods; making farm plans, wq analysis

File Name: (crops.shp)
Time Period of Content: 9/23/00
Attribute Data: (Database field names - ID, fld#, Tract#, Farm#, Acres)
Directory Path: (d:\kitcounty\crops.shp)
Dataset Format: (ArcView shapefile)
Dataset size in kB: (3000 kb)
Source Scale: (1:4000)
Projection: (State Plane)
Zone: (South Zone)
Datum: (NAD27)
Developer: (Nicole McCoy,GIS Specialist,Kittitas County COnservation District)
Source Date: (5/15/97)
Publication Date: (5/25/00)
Data Dictionary: (GPS only)

Updates: (keep adding onto this template when data is changed).

Include date, description of change made, and who did it.

Note: The ESRI Version 8 ArcGIS comes with metadata templates that can be customized.

3.2 Adding Scripts & Extensions

In addition to the tools, buttons and features that come preloaded with ArcView there are many scripts and extensions helpful for Conservation Districts that you can get for free. Because GIS has so many uses and applications it would be impossible to include all of the possible uses in ArcView out of the box.

In ArcView, under the "Help" menu, there are additional sample scripts and extensions located at:

Help Topics [Contents]
    Extensions
    Sample Scripts & Extensions

There are many resources on the internet that provide information, help, data, and sample scripts and extensions for the various sub-disciplines of GIS including conservation GIS. Most of these resources represent tremendous amounts of time and energy by dedicated people and organizations throughout the world. No matter what you need to do in ArcView someone has probably written a script or extension that does it. The trick is to know what you want to do, how to find a script or extension that does it, and how to make the script or extension useable in ArcView. The following web sites will allow you to search and will link you to the extensions you want:

www.esri.com/arcscripts - gives a search engine and lists scripts and extensions in alphabetical order (keep in mind there are lots!)

www.commenspace.org/ , then click "ArcView Scripts" to the left, scroll to the bottom and under "Additional ArcView and Avenue Resources…" click "Essential Extensions and Scripts". This site lists scripts and extensions by category, then links you directly to the ESRI arcscripts description page. This site is very useful.

EXERCISE 2 Use the ESRI Web Site to Find Specific Scripts And Extensions

1. Go to *www.esri.com/arcscripts* (Figure 3.5)

Search by the Keywords, "Intersection Points of Polylines or Polygons".

Arc View scripts are mostly written in the Avenue language and have the file extension **.ave**. ArcView extensions have the file extension **.avx**.

Figure 3.5

For this exercise you will search for the script called **Intersection Points of Polylines or Poylgons**. The file name is **polyint2pnt.zip**.

This script can be used for creating a point theme where two lines cross. An example Conservation District application for this script would be to do a culvert inventory in a watershed. You could use the script to locate where roads intersect streams. The resulting point theme could then be checked in the field and geo-referenced with GPS. The theme table could then be edited to include attribute data such as culvert size, ownership, blocking or non-blocking, date inventoried etc.

The search results shown will show you a basic description of what the script does along with such information as the author, category and date the script was written.

You should create a new folder in **Windows Explorer** for downloaded ArcView scripts and extensions so you can easily find them when you are in ArcView. If you download a sample extension you need to move the file to the EXT32 folder in ArcView. *C:\ESRI\AV_GIS30\ARCVIEW\EXT32*. Sometimes an extension comes with a **.dll** file. This usually goes in the BIN32 folder, but read the README file that comes with the extension to be certain.

3.3 Customizing the GUI

ArcView "out-of-the-box" comes with the GUI that you are familiar with. However you can add buttons, delete, buttons, add existing scripts and customize the behavior and look of the GUI with Avenue scripts. In the following exercise you will load the Avenue script you just downloaded from the ESRI ArcScripts web page, bring it into ArcView and run it.

EXERCISE 3 Customizing the GUI

1. Load the script

A. Open ArcView. Go to the "Scripts" icon in the Project Window and click "New".

B. In the Script window, click "Load Text File" button to navigate to the location of the file, "polyint2pnt.ave" and add the script to the new script window.

C. Use the compile button to prepare the script for use.

D. Rename the script to something recognizable so you can pick it out the list of scripts already in ArcView. Go to **Script - Properties** and rename the script to "line intersect".

2. Customize the GUI Using the Script

A. In the Project window, double click in the gray area to the right of the button bar. The customize dialog box will appear. This is where you will do simple customizing in ArcView.

B. Change the **Type** to **View** and **Category** to **Buttons** and click **New**. You will now see a blank button appear as in Figure 3.7.

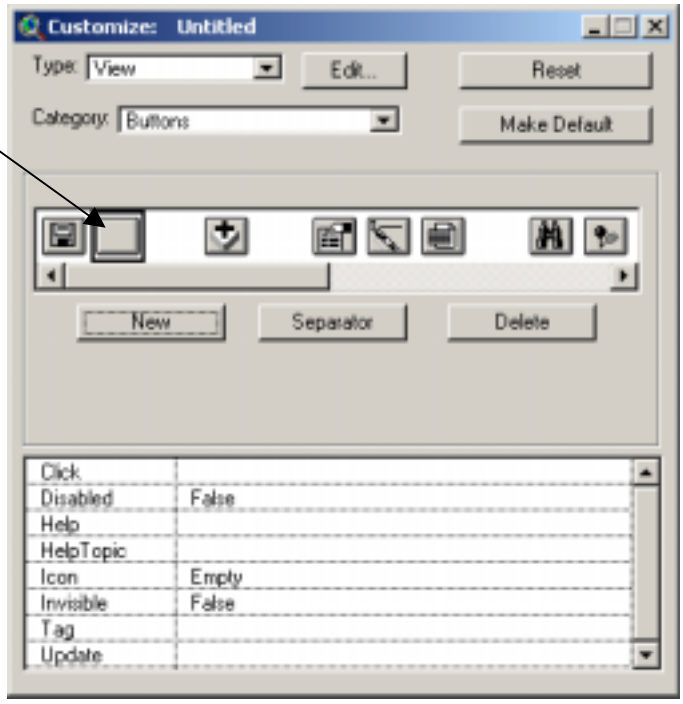


Figure 3.7

C. Double click on the area that says “Click”. This associates the button with the script. The **Script Manager** will appear (Figure 3.8). Scroll down and find the script you named “line intersect”. Click OK.

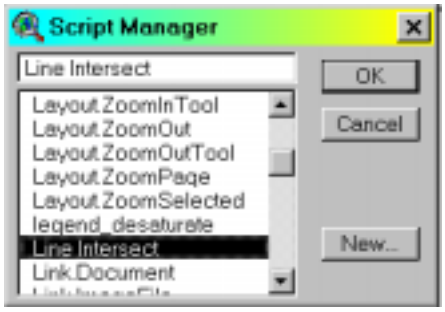


Figure 3.8

D. Double click on the area that says “Help” and type a very short description of what the button will do. Type: “Intersect 2 line themes and create a point theme”. Click “OK”.

E. Double click on the area that says “Help Topics” and type an even shorter description followed by two slashes. For Example: Intersect Line Themes//. Click OK. The two slashes will cause a yellow information box to show up right below the button when you move your mouse cursor over it.

F. Double click on the area that says “Icon” and the Icon Manager will appear (Figure 3.9). Select an Icon that you can associate with the script and is not used by another button; the “footprint”. Click OK.

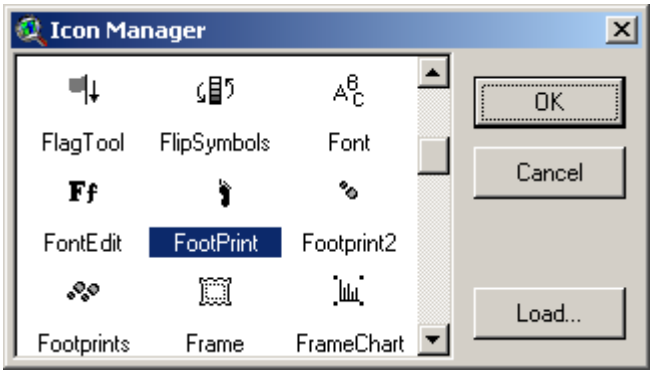


Figure 3.9

G. Now close the Customize Dialog Box by clicking the “X” in the upper right.

H. Leave “Invisible” to “False” and “Tag” and “Update” blank.

Note: To make the button always appear in each new Project, click “Make Default”; this option will only work if all of your extensions are closed. Reset will change the GUI (graphical user interface) back to the default ArcView settings.

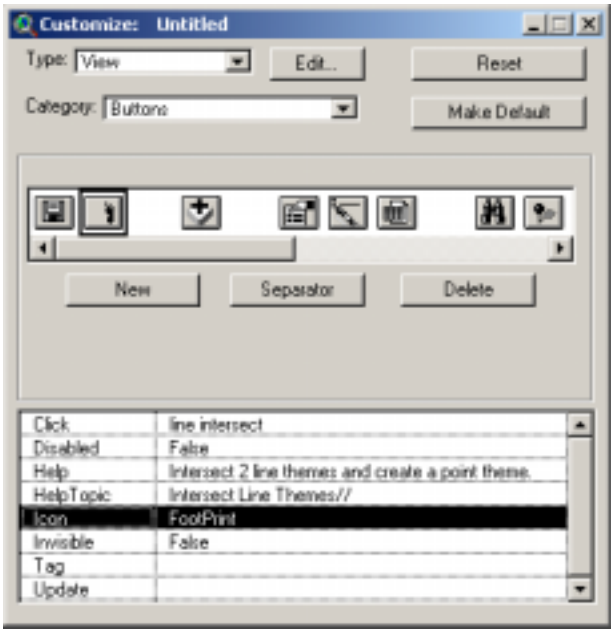


Figure 3.10

Figure 3.10 demonstrates what the customize dialog box will look like once you complete the steps. Notice the new button in the View window.

4.0 Geoprocessing, Advanced Data Editing, & GIS Modeling With Vector Data

What you will learn:

- Introduction to spatial modeling
- Geoprocessing operations using the Geoprocessing Wizard
- A Binary GIS modeling exercise
- Tools in the XTools extension

Types of GIS Models

A GIS model is a manageable abstraction of reality just as a map is. It allows you to study spatial relationships between various types of phenomenon. With ArcView it is possible to develop and run many types of models. This chapter address modeling that can be done using vector data only. The Arc View Spatial Analyst extension with the added Model Builder extension allow you to perform more detailed and sophisticated modeling using raster data. Using these extensions is shown in later chapters.

There are generally three types of GIS models:

Binary

Binary models are used to find areas that meet certain criteria. For example, to find the best place to locate a warehouse distribution center it would need to be close to major highways, have cheap rent, and be centrally located. The first exercise is used to create a binary model from well and soil data.

Suitability

Suitability models are used to identify areas that are suitable based on a numbering scale. The numbers are assigned based on importance. An overall weight is used to normalize the final values. In the above example you could determine that cheap rent is more important than proximity to roads. With that in mind you would assign a higher value to rent price. The results of your analysis would range from bad to good. If you performed your analysis and found no suitable sites you would have to adjust your model. There is a greater level of flexibility with this type of model than the binary type.

Predictive

Predictive models are used to identify probable locations of geographic phenomenon. They are developed by experts in their field with years of

experience based on detailed research and statistical analysis. These types of models usually consist of an equation that can be applied to a GIS database. Examples include soil erosion models, urban growth models and predictive wildlife distribution models.

Designing a model

When developing a GIS model it is important to be methodical. If you are not you can drown in complexity. It is also important to break the problem down into manageable sections. Flow charts can be very helpful for understanding and planning the process. Here is a procedure you can follow for developing a model:

- State the problem
- Determine Criteria
- Break down the problem into a series of solvable objectives
- Assign values of suitability to the objectives (For Suitability Type Models)
- Solve the problem

4.1 Geoprocessing Wizard

Before you can run a model you usually have to prepare you GIS data. This is known as Geoprocessing. ArcView provides the Geoprocessing Wizard for this. This wizard-based interface allows you to perform many ARC/INFO overlay functions in ArcView such as Dissolve, Merge, Clip, Intersect, Union, and Assign data by location (Spatial Join). The wizard describes each function, shows a diagram and walks you through the steps as seen in Figure 4.1. It also has a button called "More about…" which is a great resource for understanding Geoprocessing in detail. X-Tools, a free extension developed by the Oregon Department of Forestry can also be used to perform many of the same geoprocessing functions as the Arc View Wizard.

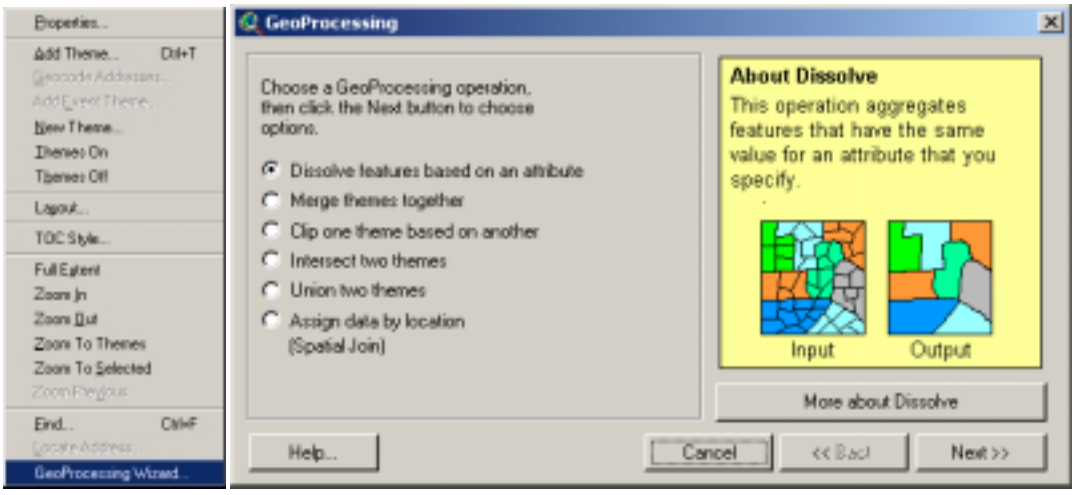


Figure 4.1

EXERCISE 1 Geoprocessing, Spatial Modeling & Analysis With Vector Data

Here is the scenario: Your Conservation District has just received a grant to study water quality data for wells in the Black River Watershed. Your technicians need to test these wells twice a month for certain water quality parameters.

As the GIS specialist you have been given the task of locating the wells that will be monitored in the study. Based on previous research the wells that you are looking for must meet the following Criteria:

- Well drilled before 1985
- < 50 feet deep
- 200 feet from a road or stream
- At least 100 feet from a wetland or lake
- In one of the following soil types:
    - Alderwood Gravelly Sandy Loam
    - Everet Very Gravelly Sandy Loam

Think of how difficult this problem would be without a GIS. How would you do it?

As you can see we have stated the problem and determined the criteria that we are looking for with this binary model. In order to continue we need to determine the data that we will need. Looking at the criteria it seems apparent that we will need the following themes:

- Black River Watershed Boundary
- Wells
- Roads
- Streams
- Wetlands
- Lakes
- Soils

In order to prepare for the analysis the themes must be prepared for the analysis. This will involve several geoprocessing operations such as merging, clipping, intersecting, and unioning. Remember that we only need data that covers our study area which is the sub-basin of the Chehalis watershed. Some of the themes cover an area larger than the Chehalis Watershed or only cover part of it. When you perform the following operations think of what process you would use and why.

Open a new project in ArcView. Open a new view and add all of the themes in **\GIS Data\BlackRiver** folder. Symbolize each theme to your preference. Be sure your view properties map units and distance units are set to feet. Set your working directory to C:\GISData.

The first step is to make a new theme of the Black River sub-basin. Make "Subbasins.shp" active. Enter the following query expression in the Query Builder: ([Basin] = "BLACK RIVER"). Convert to a shapefile and call it "Blkriv_sub.shp".

You will be using all of the features of the Geoprocessing Wizard to prepare your data for analysis. Turn on the Geoprocessing extension under File-Extensions.

1) Dissolve "Soils"

The dissolve process is used to simplify data. Be careful how you use it because dissolving data involves data loss. In this case we need the soil theme to be differentiated only by name. The slope designation is not important. In addition the dissolve process will be used to combine separate polygons with the same soil designation.

The dissolve field in the soils theme was created for you to save time for this exercise. Look at the dissolve field for a minute to see how it works. Notice that each soil name has a different code and soils with the same name but different slope designations have been combined.

Dissolve the Soils theme based on a pre-existing dissolve field.

Open the Geoprocessing Wizard. Make sure the Dissolve radio button is checked and click Next. Choose Soils as the theme to dissolve and select Dissolve as the attribute to dissolve. Change the name of the output file to DissolveSoils.shp (Figure 4.2)

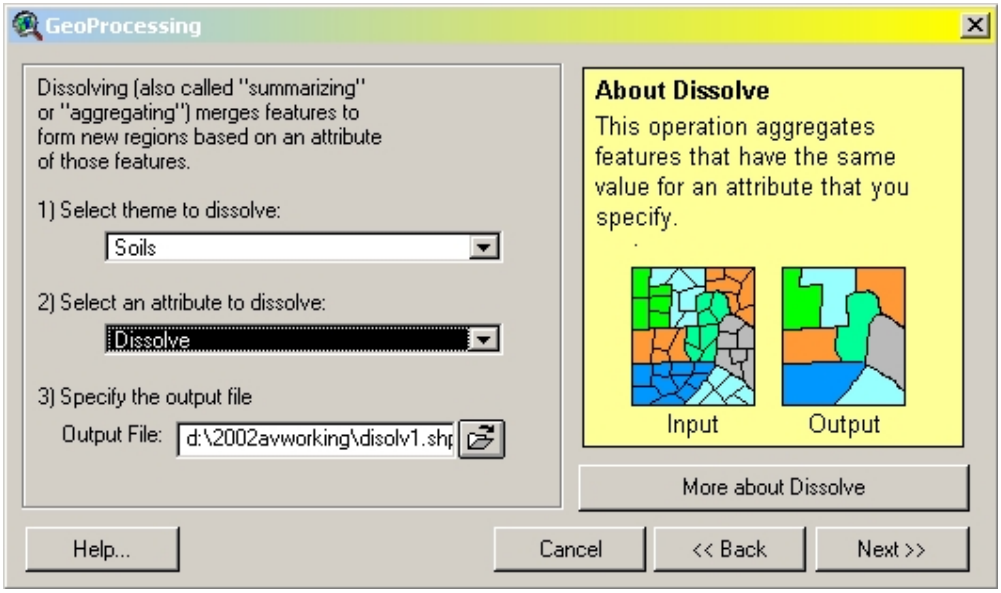


Figure 4.2

Click next and choose First_Muname by First as an additional field to be included in the output file.

Figure 4.3

Click finish. Notice that before you ran the Dissolve operation the attribute table for the Soils theme contained 1250 records. The new dissolved theme only contains 46 records. The data has been simplified a great deal. This makes it easier and faster to query and process.

Turn off the original soils theme.

2) Merge "Roads"

Merging is useful when you want to append two themes with exactly the same features such as roads, crop type, etc. Make sure the themes don't have any overlapping areas. If they do you can still merge the themes, but the result will be duplicate records where there is overlap. This can cause major problems in your database. Only the fields that are the same in both tables will be retained. It there are additional fields in a table choose that table's Theme to merge to. Otherwise you could lose data. In this case both tables share the same fields so there isn't risk of losing data.

Merge "roadseast.shp" and "roads.shp "themes. Use fields from either table.

Open the Geoprocessing Wizard. Make sure the Merge radio button is checked and click Next. Choose Soils as the theme to dissolve and select Dissolve as the attribute to dissolve. Change the name of the output file to RoadsAll.shp (Figure 4.4). Click Finish.

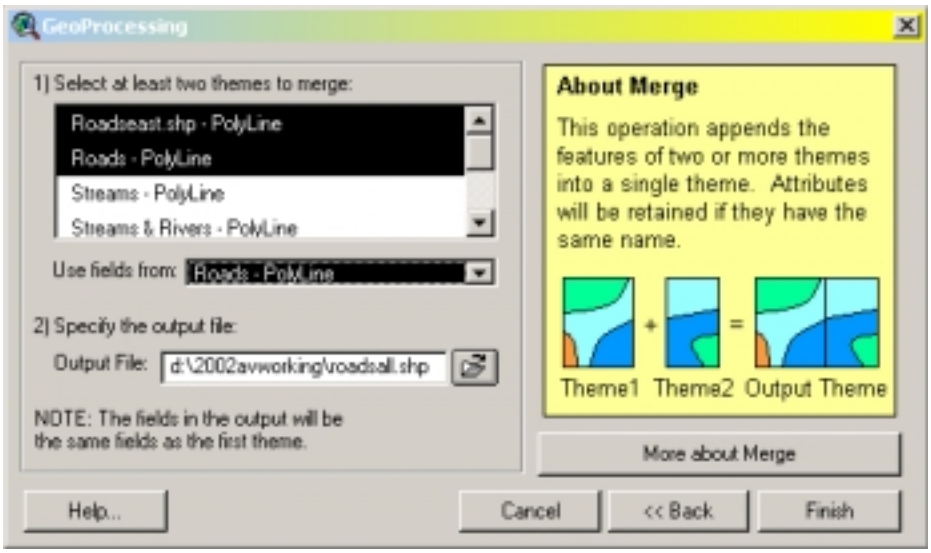


Figure4.4

Turn off original roads themes.

3) Clip "Soils", "Wells" and "Roads"

Clipping is one of the most useful tools in the Geoprocessing wizard. It's the "cookie cutter" approach. All of the attributes are retained in the input Theme and only the records within the overlay Theme are left in the new Theme. This is beneficial when you want to make a Theme smaller or clip it to a specified boundary like a watershed, field, or other specified area. You can also clip using selected features. This is nice because you don't need to make a new Theme first. The input Theme can be a point, line, or polygon and the overlay Theme must be a polygon.

Clip the dissolvesoils.shp theme with the Black River sub-basin theme.

Open the Geoprocessing Wizard. Make sure the Clip radio button is checked and click Next. Choose dissolvesoils as the theme to clip and select blkriv_sub.shp as the overlay theme. Change the name of the output file to blkriv_soils.shp (Figure 4.5) Click Finish.

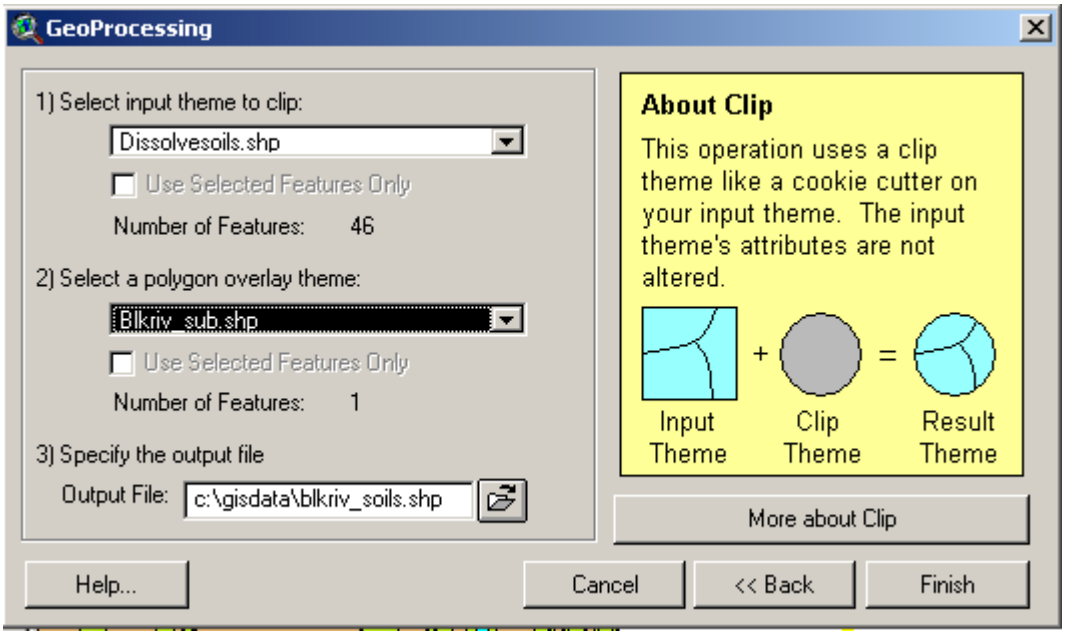


Figure 4.5

Notice how much smaller your Soils dataset is. You only need to analyze the data that is in your study area, i.e. the Black River subwatershed.

Follow the same steps to clip roads. "allroads.shp" is the input theme and "blkriv_sub.shp" is the overlay theme. Name it "blkriv_rds.shp".

Follow the same steps to clip wells. "wells.shp" is the input theme and "blkriv_sub.shp" is the overlay theme. Name it "blkriv_wells.shp".

Turn off the original dissolvesoils and allroads themes.

4) Intersect

Intersecting is useful when you want to clip the input Theme (like streams) to the output Theme (like sub-basin) and retain attributes from both Themes. This is useful for such tasks as determining the amount of stream miles within a sub-basin. The input Theme can be a point, line, or polygon and the overlay Theme must be a polygon.

Intersect the Streams Theme with the Black River Sub-Basin theme.

Open the Geoprocessing Wizard. Make sure the Intersect radio button is checked and click Next. Choose Streams & Rivers as the theme to Intersect and select Black River Watershed Sub-Basins as the overlay theme. Change the name of the output file to blkriv_strms.shp (Figure 4.6) Click Finish. Open the attribute table for your new theme and examine what has changed. Notice that the attribute table now contains the attributes of both themes that were intersected.

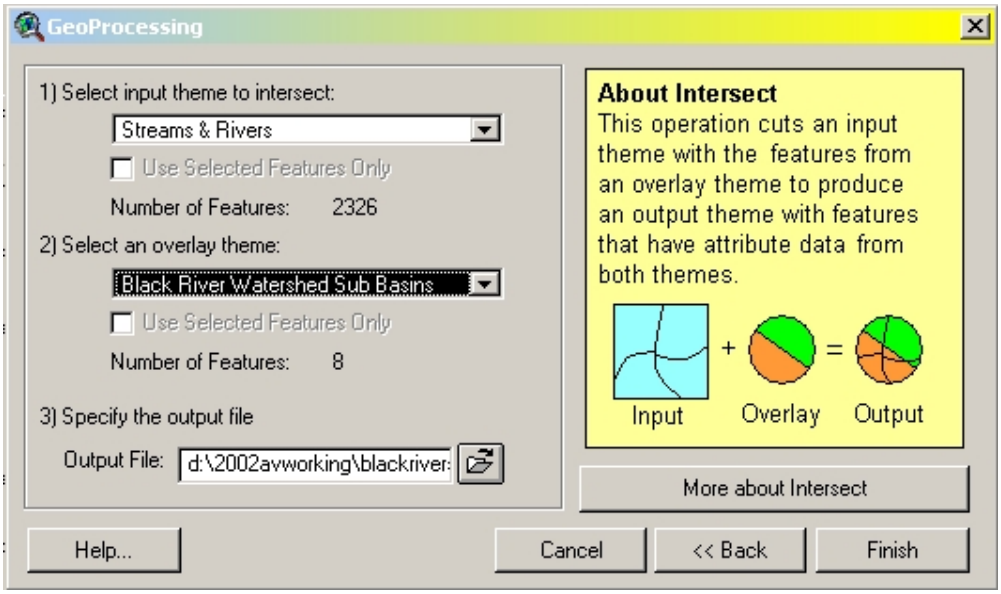


Figure 4.6
Turn off the original streams theme.

5) Union

Union does the same thing as Intersect except you can only use polygon themes and the full extent of both features are present. We need to locate wells that are 100' from a wetland or lake, therefore we will Union the Wetlands and Lakes themes.

Union the Wetlands and the Lakes Themes

Open the Geoprocessing Wizard. Make sure the Union radio button is checked and click Next. Choose Wetlands as the input theme to Union and select Lakes as the overlay theme. Change the name of the output file to un_wetlakes.shp (Figure 4.7) Click Finish.

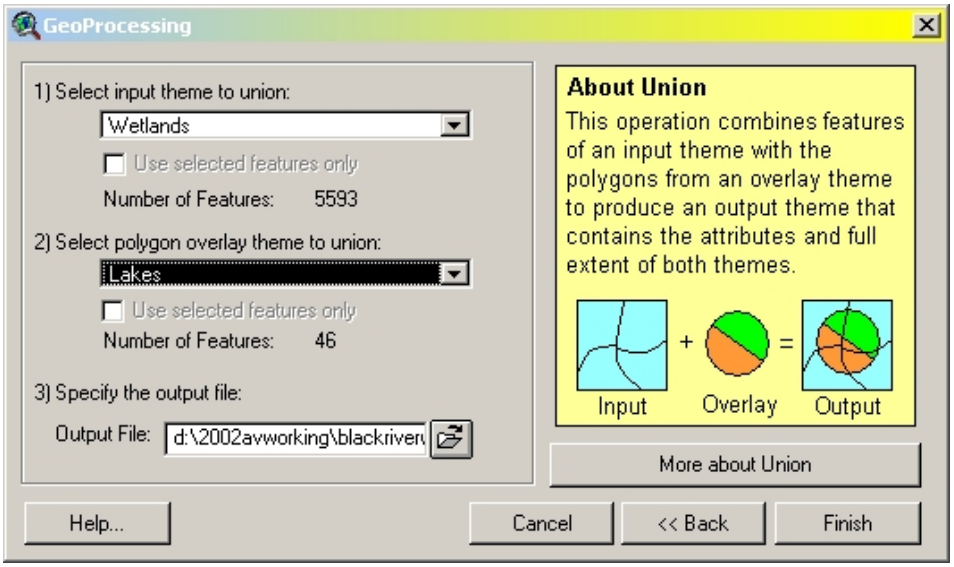


Figure 4.7

Clip un_wetlakes.shp with blkriv_sub.shp and call it “blkriv_wetlks.shp”.

Turn off the original wetlands, lakes and union themes.

6) Assign Data By Location (Spatial Join)

Use Assign data by location when you want to use a spatial relationship to join data from the attribute table of one Theme to the attribute table of another Theme. Depending on the type of data you have, the join will be one of three types of spatial relationships: 'nearest', 'inside', or 'part of'. This operation works with point, line or polygon themes.

Assign Data By Location for Wells and Dissolved Soils

For this Geoprocessing exercise we are going to use dissolvesoils.shp and blkriv_wells.shp. Remember that for our analysis we need to know what soil type each well is located in. To find this out we will perform a spatial join with the Wells and Dissolved Soils themes.

Open the Geoprocessing Wizard. Make sure the Assign Data By Location radio button is checked and click Next. Choose Wells as the input theme to assign data to and select as the theme to assign data from (Figure 4.8). Click Finish. Notice that after performing this operation you are not left with a new theme. Only the themes attribute tables are joined.

Open the table for wells. Notice the soils attributes which are appended to it.

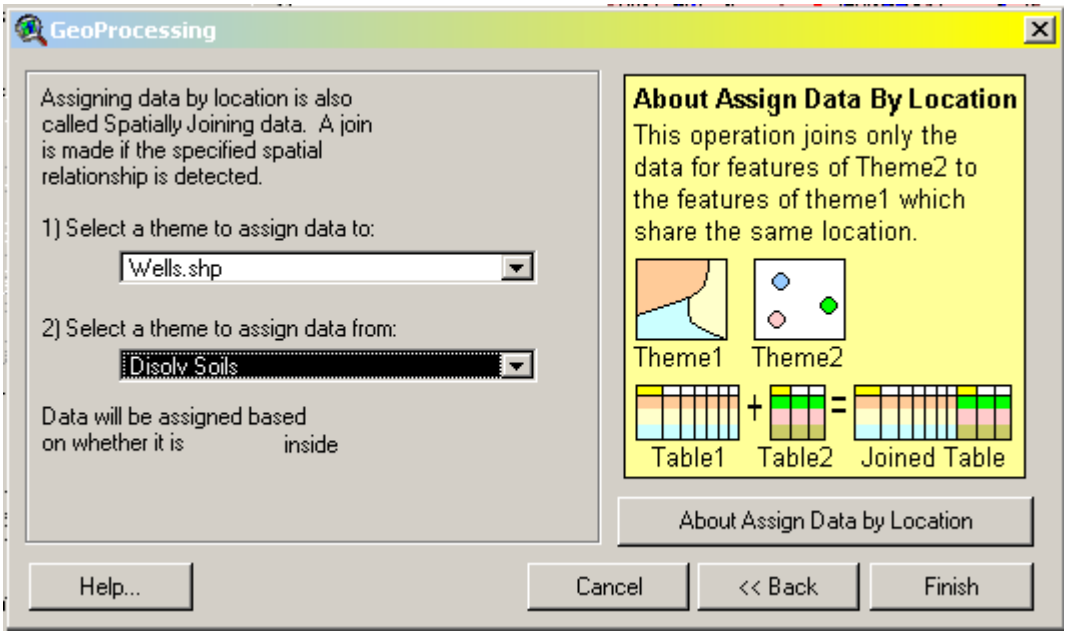


Figure 4.8

4.2 Buffer Wizard and Field Calculator

The Buffer Wizard will be used to determine the areas that are 200 feet from a road or stream and at least 100 feet from a wetland or lake. The Field Calculator will be used to continue the analysis. Keep in mind we are using all of the new data files within the Black River sub-basin from this point on.

EXERCISE 2 Buffering, Querying and Calculating Spatial Data

1. Buffer the Roads and Streams themes with a 200 foot buffer and Lakes and Wetlands theme with a 100 foot buffer using the Buffer Wizard. Keep the default buffer names.

2. Perform a Union in the Geoprocessing wizard on these three buffer themes that you recently created:
    - 100 foot Wetland & Lake Buffer
    - 200 foot Road Buffer
    - 200 Stream Buffer

Remember that you can only Union two themes at a time. Name the final unioned themes "allbuff.shp"

Add a field to the "allbuff.shp" table and call it "Dissolve". Set it as a "string" with 5 characters. Make sure it is active and edit the dissolve field in **Field Calculator** by populating every record with "1". Type "1" (with quotes) in the expression box. Stop editing the table, save edits and open the Geoprocessing Wizard.

1. Dissolve your buffer theme using the Dissolve field. Name your theme BlackAllBuff.shp Do not choose any other operations to be included in the output file.

Now that you have prepared all of your themes you can perform the first part of the analysis.

2. Select wells that are completely within BlackAllBuff.shp.

Make Wells the active theme in you View's Table of Contents. Go to **Theme – Select By Theme** in the pull down menu. Select your combined Buffer theme in the ***Selected Features of*** window and select the ***Are Completely Within*** property. See Figure 4.9. Click New Set and open up the Attribute Table.

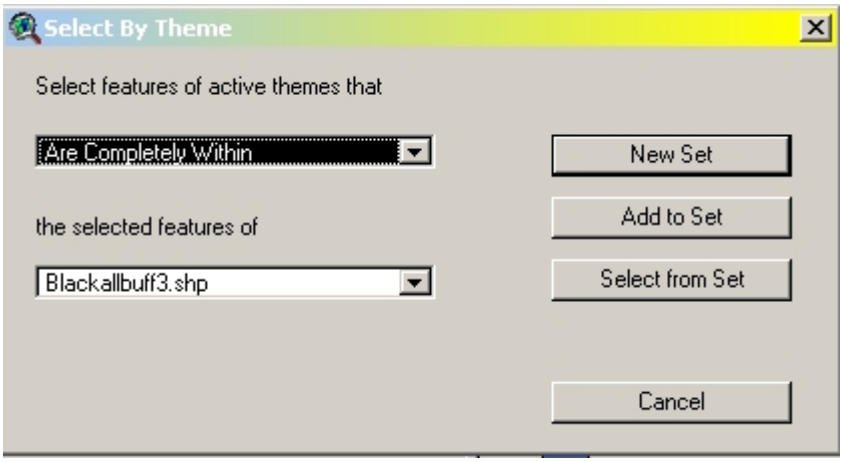


Figure 4.9

3. Create a boolean field called "Instdy" to have a permanent query of the wells within the study area.

Click on the Switch Selection Button. 
You should have 48 records selected in the Wells theme. Understand that you are using the Switch Selection Button because you are going to use the Wells that are not completely contained in the combined buffer theme that you created. That is, you can query for what you are not going to use and use "switch selection" to get to what you are really interested in.

Start editing the table and add a new field called **InStdy** (meaning "in study area"). Make it **Boolean**. Make sure the InStdy field is active and open the Field Calculator. Type **True** and click OK. Click on the Switch Selection Button.  , open the Field Calculator and type **False**. Stop editing and save the edits to the table. Now you have a permanent record of your spatial query.

4. Create a Selection Set using Theme Properties to select wells within BlackAllBuff theme.

Go to **Theme – Properties** and click on the Query button under **Definition** icon. Enter ([InStudy]) as shown in Figure 4.10. Click OK. Now look at the number of records in the attribute table for wells. There should be 48 records.

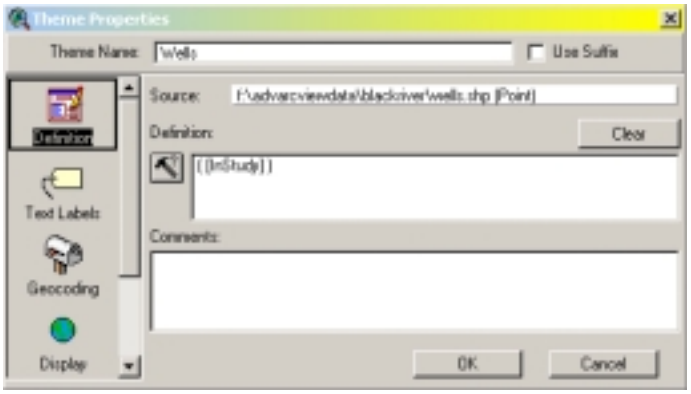


Figure 4.10

5. Simplify the "look" of your table.

Before we can begin the second part of our analysis we need to modify the attribute table of the Blkriv_wells.shp theme to make it easy to use. Open the attribute table for the Wells theme and go to **Table – Properties** in the pull down menu.

Make **Shape, Wells_id, Elevation, DrillDate, and First_Muna** the only visible fields. Make the Alias for **First_Muna *Soil Type***. Click OK.

Now you are ready for the final part of the analysis. Remember that you performed a spatial join with the dissolved soils theme and the wells theme and that you saw the soil type field in the Wells theme. You are interested in comparing the depth of wells to the soil type.

6. Create a Summary Table showing Average Well Depth by Soil Type

Open the attribute table for the Wells theme. Make the **Soil Type** field active. Go to **Field – Summarize**. Add **WellDepth** to the dialog window and summarize by average (Figure 4.11). Click OK.

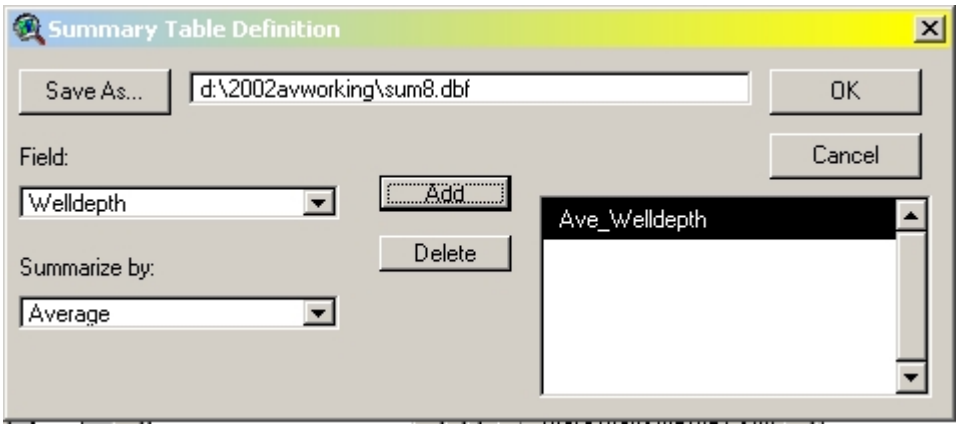


Figure 4.11

You should see a new table with the**, Soil Type, Count and Average Well Depth** fields. Look at the data. Is there anything that stands out? Sort the WellDepth field and look at what soil types have the deepest and shallowest wells. Sort the Count Field and examine which soil type has the most wells drilled in it. Can you infer anything from this? Perhaps, but remember that most models are incomplete abstractions of reality. There may be unaccounted for factors in your model.

The next step would be perform a statistical regression analysis on the data to see if there is any correlation between well depth and soil type. This would be beyond the scope of this exercise but you can see how statistical analysis plays an important part in the study of GIS spatial data as well as other types of tabular data.

7. Perform the final query to determine which wells will be studied.

Now we are ready solve our GIS problem that was stated at the beginning of the exercise. If you recall the criteria was:

- wells drilled prior to 1985
- < 50 feet deep
- 200 feet from a road or stream
- At least 100 feet from a wetland or lake
- In one of the following soil types:
    - Alderwood Gravelly Sandy Loam
    - Everett Very Gravelly Sandy Loam

We have already selected wells that meet some of these criteria through our buffer creation and intersect geoprocessing operations. Namely, all of the criteria dealing with distance i.e. 200 feet from a road or stream and 100 feet from a wetland or lake. The remaining selection of wells can be accomplished with a query of the attribute table of the Wells theme.

Open the attribute table of the Blkriv_wells.shp theme and Click the Query Builder button 

Enter the following expression:

(([DrillDate] < 19850115.AsDate)) and ([Welldepth] < 50) and ([Soil Type] = "ALDERWOOD GRAVELLY SANDY LOAM, 3 TO 15 PERCENT SLOPES") or ([Soil Type] = "EVERETT VERY GRAVELLY SANDY LOAM, 15 TO 30 PERCENT SLOPES")

If you get too many syntax errors in your expression you can perform each query separately and use the **Add to Set** button when you run each one. This is more time consuming but may help prevent syntax frustration syndrome or SFS.

Either way you choose to perform the query you should get a result of 8 records. They meet all of the criteria stated in our problem at the beginning of the exercise. These are the wells that your technicians will test and is the answer, so to speak, of our binary GIS modeling problem.

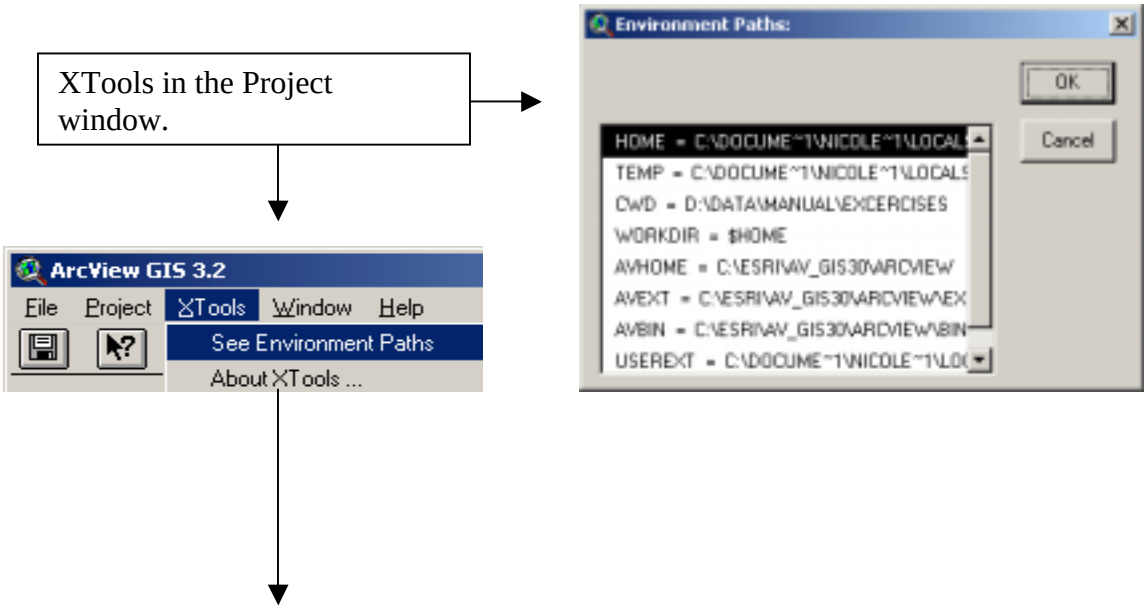
In order to save the results of your query and the model as a whole save the selected set as a new shapefile called “stdy_wells.shp”.

4.3 X-Tools Extension

This extension is made up of menu items in the Project, View, and Table, which do additional analysis functions in ArcView. It was available before the Geoprocessing wizard which came with ArcView 3.1. Now the Geoprocessing wizard functions to utilize some of the applications offered in XTools. The dialog is different and sometimes easier to navigate. It also allows for more flexibility in selecting output. It is designed to operate on shapefiles and coverages.

To get it, go to www.odf.state.or.us/sfgis. There are easy-to-follow downloading and installation instructions. Be sure to read this before downloading the extension.

Note: ESRI does not support any scripts or extensions which they haven't developed and tested.



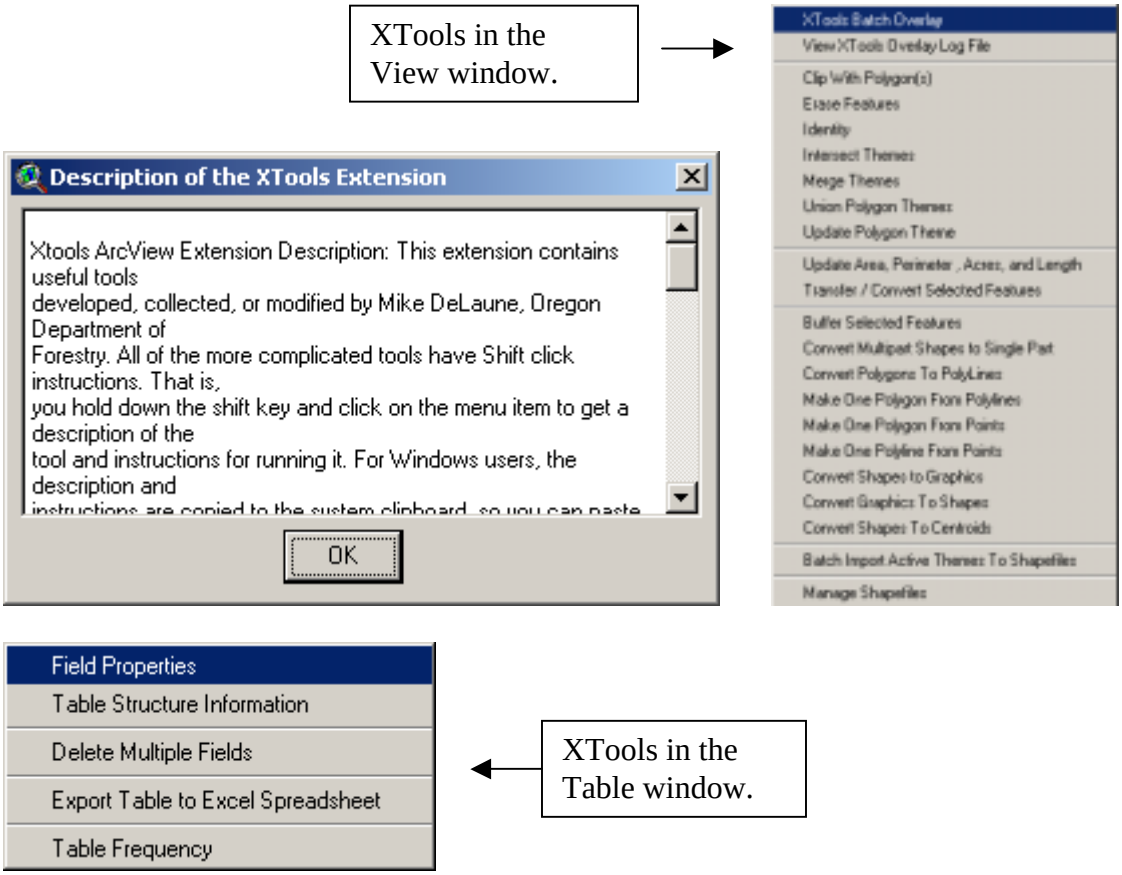


Figure 4.2

Refer to Figure 4.3 to see what the XTools menu items are in all of the documents.

EXERCISE 3 XTools Applications

In the following exercises XTools will already be installed. Make sure it is activated under "Extensions" in the File menu. You will be using the same Themes that are in View 1.

all_wdsoils.shp
kittitas.shp
ellensburg.shp
hydro.shp
subwat_sp.shp
fields.shp
soils.shp
crep_hydro.shp
poss_culv.shp

Note: The Clip, Intersect, Merge and Union applications do the same thing as in the Geoprocessing wizard with the acception of different dialog.

You can get more information about a specific tool by holding down the "Shift" key and "clicking" on the menu name at the same time ("shiftclick"). This is a useful help function. You also have the option of saving the information to a text editor and printing.

1. Copy and paste the Themes above into a new View

In proj4.apr copy and paste the list of Themes into a new View. Call the View "XTools". Select the Theme "subwat_sp.shp" and query with following expression: *Sub_waters = 55*. You will need this for some exercises.

2. Clip With Polygons

From the **XTools** pull down menu, select "Clip with Polygon(s)". Select "poss_culv.shp" as input Theme and "subwat_sp.shp" as the overlay Theme (or clip Theme). Name the output Theme "clip1.shp". The result is the same as using the Geoprocessing Wizard. It also clips selected features. Turn off "clip1.shp".

3. Erase Features

You would want to use this application to create a file that excludes features within the overlay Theme.

In **XTools** click "Erase Features". Select "poss_culv.shp" as the Theme that contains features you want to erase. Select "subwat_sp.shp" as the polygon Theme that will be used to erase the previous Theme's features. Name it "erase1.shp". Turn off "poss_culv.shp" and see what is left.

3. Identity

Find out how many miles of hydro overlaps with subbasin. The input Theme is a point, line, or polygon and the overlay Theme is a polygon. All of the input Theme will still be there.

Poly – splits the input Themes where they overlap the Identity Theme and builds them into a new Theme.
Line – splits the input Theme where they overlap the Identity Theme and builds them into a new Theme.
Point – transfers the attributes of the Identity Theme polygon to each point that falls within it.

A. Turn on "hydro.shp" and "subwat_sp.shp". In XTools click "Identity". Select "hydro.shp" as the input Theme. Select the first three fields for output. Select "subwat_sp" as overlay Theme. Select all fields for output. Name it "identi1.shp" and turn on the Theme.
B. Start editing. Click on portion of hydro outside the subwatershed boundary. Click on portion inside the subwatershed. The outcome makes it easy to determine miles of a stream inside or outside a selected watershed. (Refer to page 4-48 to convert feet to miles).

4. Intersect Themes

Turn on "crep_hydro.shp" and "subwat_sp.shp". In **XTools** click "Intersect Themes". Select "crep_hydro.shp" as input Theme and select "spawning" and "name" fields. Select "subwat_sp.shp" as the polygon Theme to overlay, then select the "ID" field. Name the output

Theme “intersect1.shp”. The result is similar to using the Geoprocessing Wizard with the exceptions that you can specify the fields you want in the output file. Turn off “crep_hydro.shp”, “subwat_sp.shp” and “intersect1.shp”.

5. Merge Themes

Turn on “Ellensburg.shp” and “Kittitas.shp”. In **XTools** click “Merge Themes”. Select “Ellensburg.shp” as the Theme that contains the field you want to preserve. Select “Kittitas.shp” as the Theme to merge with (you have the option of selecting more than one Theme). Name it “merge1.shp”. This is the same as in the Geoprocessing Wizard.

6. Union Polygon Themes

This is similar to intersecting Themes, but you can only use polygons as the input and overlay Themes. The output Theme contains the combined polygons of both Themes. You can select the fields for the output Theme.

7. Overlay Log File

Go to **XTools** menu , “XTools Overlay Log File”. It will list each XTools Clip, Erase, Identity, Intersect, Union and Update overlay operation run in that project. It won’t log operations done in the Geoprocessing Wizard. The log file is named Xtlog.txt which is automatically created. Log information will be appended when additional
operations are run.

8. Update Area, Perimeter, Acres, and Length

This function is the most valuable for our purposes. It is not available in the Geoprocessing wizard.

Area, perimeter and acres fields are automatically calculated for polygons and length is calculated for lines if the fields don’t already exist. Calculations are in feet or meters depending on the XTools file you are using. Each time an area is edited, XTools must be ran again to update changes. Rerun the script if Themes are reprojected.

Select “Update Area, Perimeter, Acres, and Length”. Choose “Theme2.shp” to update. Make sure “Theme2.shp” is the active Theme and open the table. Notice the new fields that are added.

9. XTools applications in the Table window

There are two useful tools in XTools for Tables: **Field Properties** and **Delete Multiple Fields.** “Field Properties” allows you to see all the parameters set for that field (Figure 4.3) and “Delete Multiple Fields” (Figure 4.4) allows you to delete more than one field at a time and asks if you really want it to delete it before the task is final. These options are not available anywhere else in ArcView.

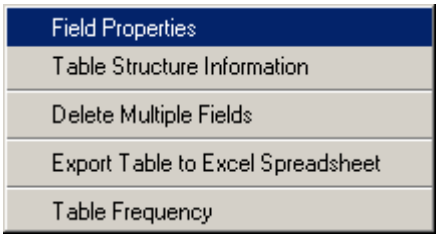


Figure 4.3

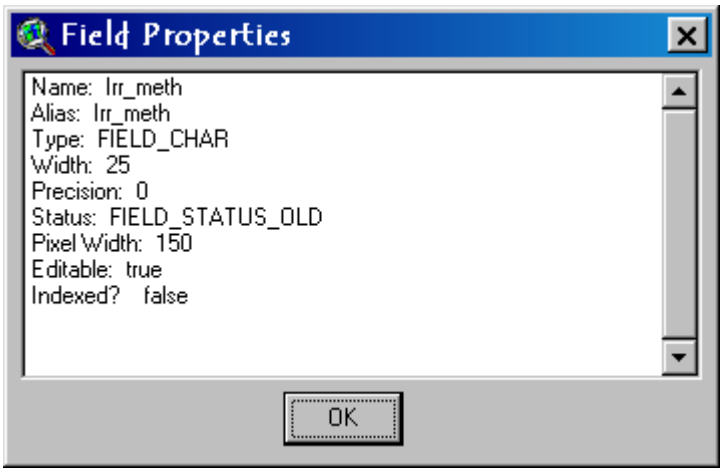


Figure 4.4

5.0 Cartographic Design & Layouts

What you will learn:

- Types of maps
- Cartographic principles
- Map Composition
- Cartographic Design
- Layout Tips

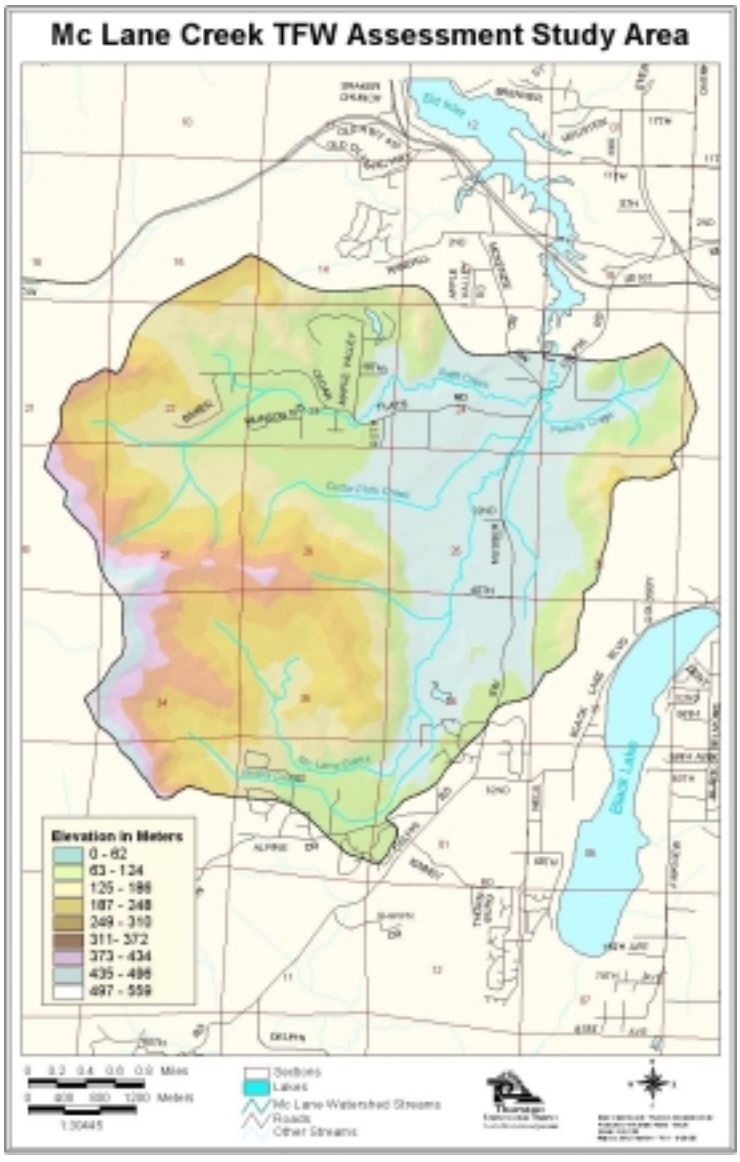


Figure 5.1

For the most part there are two general types of maps. Maps that show information about the location of features are known as Reference Maps. A road map of Washington or a USGS topographical map are both considered reference maps. Maps that show information about the statistical distribution of specific information or data are know as Thematic Maps. Other examples would be a map of dairy field locations which would be a reference map and a map of the distribution of dairies by county in Washington would be a thematic map.

Figure 5.1 shows a map that is both a reference map and a thematic map. The location of the study area and associated roads, sections, streams and lakes are the reference elements whereas the elevation data are the thematic elements.

General Cartographic Concepts

All maps are a generalization and/or limited representation of reality. It is impossible to show all features at their actual size or in full detail. Generally, maps are smaller than the things they represent and only show what the map creator decides what is important to show. Maps are meant to communicate information. Because features cannot be shown at their actual size they must be generalized. Given these limitations, the accuracy of a map is hard to assess. What is more important is whether or not the map communicates the information it was intended to communicate.

- **Map Scale**

  What features are generalized and to what extent they are generalized is based on the scale of the map. A map is a scale model of the earth. The map scale shows what amount the reduction or enlargement is.

  For example, if the scale on a map is 1:5,000, this means that one inch on the map represents 5,000 inches in the real world. The unit of measurement is not what is important. What is important is the ratio. In other words, 1:5000 means 1 foot equals 5000 feet or 1 meter equals 5000 meters. Be careful not to mix units though. 1 inch would not represent 5000 feet.

- **Scale Representation**

  There are two ways of representing scale on a map. Graphically and verbally.

  Graphic representation of scale is represented with a scale bar.

  A verbal representation of scale would look like this: 1:70,000.

  For the most part a scale bar is easier to use and still remains accurate if a map is reduced or enlarged by photocopying. A verbal scale is more useful as a reference for the cartographer to know what scale the map was produced in or if the user of the map specifies a certain scale like 1:7920 for NRCS...

  For more information on map scales and projections see Chapter 1, Geographic Information System (GIS) Concepts in the Introduction to GIS for Conservation Districts/NRCS Training Manual.

■ Map Generalization

The term generalization in cartography means the removal of unnecessary detail. Because maps cannot show everything the mapmaker must decide which features are important and which ones are not. Some features may need to be simplified to be legible at a smaller scale. Symbols must be chosen to represent features. Also, in many cases, data may need to be classified which means divided into similar groups or values.

■ Classification

Most maps will require the data be classified in some way. Most people can only distinguish about seven classes. As a result it is not always practical to assign a unique value to every data record. For example, a soils map with 150 types of soil represented by 150 different colors would be impossible for most people to distinguish that many colors. Depending on the quality of your monitor, printer or plotter, five to seven categories is a good practical limit.

A good classification scheme should adequately describe the phenomena you are mapping. Classes should describe all possible values and should not allow overlapping. That is, having data values that can fall into two different classes.

There are several ways to classify data. The purpose of your map and the characteristics of your data set will determine which approach is best. Know your data. It also helps to have a basic understanding of statistical concepts such as mean, standard deviation, and data distribution.

Here are the classification schemes available in ArcView:

1. Natural Breaks
This is the default classification method in ArcView. This method identifies breakpoints between classes using a statistical formula (Jenk's optimization). This method is rather complex, but basically the Jenk's method minimizes the sum of the variance within each of the classes. Natural Breaks finds groupings and patterns inherent in your data.

2. Quantile
In the quantile classification method, each class contains the same number of features. Quantile classes are perhaps the easiest to understand, but they can be misleading. Population counts (as opposed to density or percentage), for example, are usually not suitable for quantile classification because only a few places are highly populated. You can overcome this distortion by increasing the number of classes. Imagine the difference, for example, if five classes are used in the chart instead of three. Quantiles are best suited for data that is linearly distributed; in other words, data that does not have disproportionate numbers of features with similar values.

3. Equal Area

This method classifies polygon features by finding breakpoints so that the total area of the polygons in each class is the approximately the same. (ArcView determines the total area of the features that have valid data values.) Classes determined with the equal area method are typically very similar to Quantile classes when the sizes of all the features are roughly the same. Equal Area will differ from Quantile if the features are of vastly different areas.

4. Equal Interval

The equal interval method divides the range of attribute values into equal sized sub-ranges. Then the features are classified based on those sub-ranges.

5. Standard Deviations

When you classify data using the standard deviations method, ArcView finds the mean value and then places class breaks above and below the mean at intervals of either 1/4, 1/2, or 1 standard deviations until all the data values are contained within the classes. ArcView will aggregate any values that are beyond three standard deviations from the mean into two classes, greater than three standard deviations above the mean ("> 3 Std Dev.") and less than three standard deviations below the mean ("< -3 Std. Dev.").

- **Symbolization**

Symbolization is the process of assigning symbols to represent features. Symbols can be pictorial such as a highway shield that represents a state highway or they can be abstract such as circles, squares or triangles.

The first step in making a map is to determine which type of geographic features are involved. Are the features being mapped points, lines or polygons? Culvert locations are point data, roads are line data, and fields are polygon data.

- **Measurement Level**

For the most part, data can be considered qualitative or quantitative. Qualitative data show differences in kind or type, with no numerical values attached. Quantitative data indicate differences in amount and can be expressed as a number although they do not have to be.

Data can also be described by measurement level. Cartographers are generally concerned with three levels: **nominal, ordinal, and interval/ratio data.** Nominal data differ in type, and cannot be ranked.
An example of nominal data would be tree species. Ordinal data can be ranked, but have only relative values (i.e. low, medium, high). With ordinal data it is possible to say that one thing is greater than another, but because there are no

numerical values associated with the data it is not possible to measure the difference between them. Interval/ratio data, on the other hand, do have numerical values attached to them. This makes it possible to measure the difference between things as well as rank them. Elevation values on a Digital Elevation Model would be interval/ratio data.

- **Data Processing**

  It is important to know how data have been manipulated or modified. If you are making a comparison between data items they should be in the same units. This may require conversion from one kind of units to another. For example, a digital elevation model may have elevation values in feet in one quad and meters in the adjacent quad.

- **Choosing Symbols**

  Symbols can be manipulated in the following ways: size, shape, orientation, pattern, hue, and value. Hue and value are two characteristics of color, the names that are assigned to different colors correspond with hue (e.g. red, blue, green). Value refers to how light or dark a color is, although value can also apply to gray. The following graphic illustrates how variables can be used with different types of data.

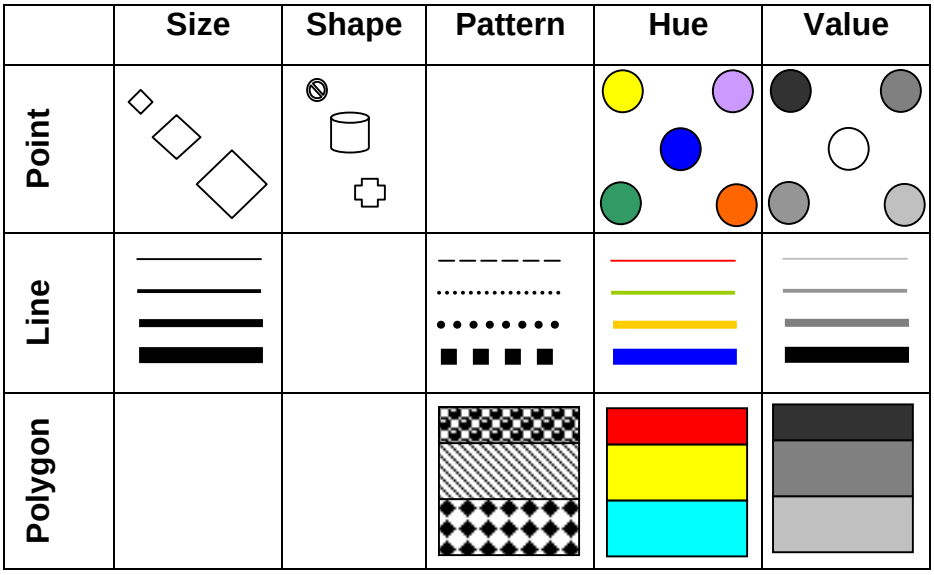


Figure 5.2

- **Symbols for Quantitative and Qualitative Data**

  Qualitative symbols should not imply a ranking. They differ only in type.

  Quantitative symbols should show a progression from low to high.

Map Composition

Your first thought about map composition should be what is your map going to show? What are the most important features? How large does your map need to be?

After you have decided what needs to be on the map you should decide on a page layout. Should you use landscape or portrait? Base your decision on the shape of the area to be portrayed in the map e.g. wide areas should be landscape, tall areas should be portrait. Remember to set up the printer before you set up the page layout because different printers usually have different margin settings. Also, decide on a paper size. If you have a plotter you have many more choices. "E" size is the largest map size you can use followed by "D" and "C". 11 x 17 is a good choice for reports.

Note: If you make a layout in the wrong paper size and want to change it, don't group the objects and stretch or shrink them to fit the new frame. This will adversely affect the scale.

Layouts should have the following information:
Without these elements the usefulness of a map becomes extremely limited.

- Title
- Spatial Features (view frame in ArcView)
- Legend
- Scale bar
- North arrow
- Projection, datum and units
- Date of data and date of map creation
- Data source(s), accuracy and author (s)

Cartographic Design Elements

For the most part, map composition is about graphic design. It helps to have some rudimentary knowledge of design elements such as balance, symmetry and visual hierarchy. The following is a list of design elements important in map composition:

- **Color**

  Use colors that attract the viewers attention to the most important elements. Avoid, using psychologically alarming colors such as red whenever possible. Remember that the colors on your screen are not going print out on your plotter or printer at the same saturation. Generally, colors will be much darker when printed. Go to the ESRI arcsripts web-page and download the script "Desaturate Legend" to tone colors down for plotting. This scripts provides a very easy way Remember that lighter colors are generally better than darker ones.

- **Visual Balance**

  Visual balance refers to the arrangement of objects in the map. (e.g. legend, north arrow, view frame, etc.) Your objects should be arranged so that the visual center of the map is slightly above the geometric center of the display. Also, think about what the map viewer's eye will be attracted to.

- **Figure-Ground Relationship**

  The figure ground relationship refers to ease at which you can tell what if front and what is in the background. Probably the best way to describe this is to use the example of an island on a map. If you just have lines representing the island it is difficult to tell whether you are looking at an island or a lake. To alleviate this problem use color or pattern. Make the island darker than the ocean or give it a more pronounced outline.

- **Clarity and Legibility**

  For the most part, this is self explanatory. Make sure all of the text on your map is the right size for its purpose. If the most important part of your map is the location dairy fields make sure that the field labels are legible.

- **Visual Hierarchy**

  This refers to the order of importance of visual elements of your map. The most important information on your map should have the most visual impact. Similarly, the least important information should have the least impact. You can accomplish this by adjusting size and color appropriately.

- **Shading Patterns**

  Be cautious about using patterns in maps. It is very easy to make a map to busy with pattern and texture. You should generally avoid using patterns. Use color instead. One use for patterns is if you need to make a map that will be reproduced in black and white. Again, use caution.

- **Text**

  Use simple fonts such as Arial so as not to distract the map view from the main information that the map portraying. Use an appropriate size font.

- **Label Placement**

  Label placement in ArcView can be tedious. You can adjust the settings for labels in ArcView by going to the *Graphics* pull down and choosing *Text and Label Defaults.* You will see the following dialog box:

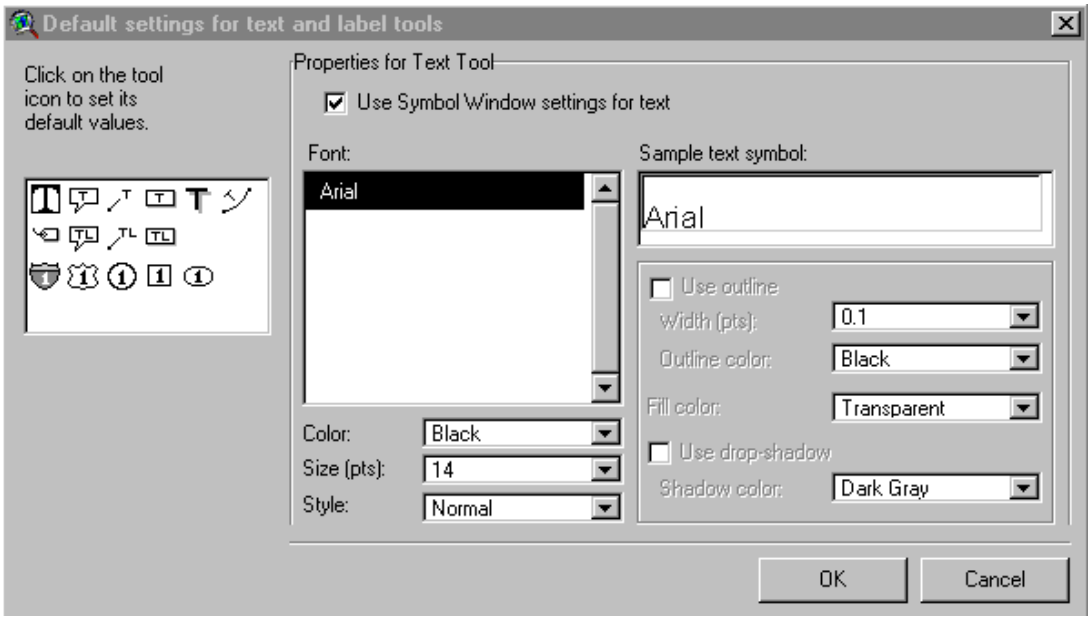


Figure 5.3

To adjust the settings click on the tool you would like to change the settings for. The middle row are the label tools. Be sure to uncheck the *Use Symbol Window Settings for Text* box. If you do not uncheck it you will not be able to change the settings.

5.1 Helpful Hints for Layouts

- Never use the Text tools for labeling. The labels will not not scale with your map. A good trick is use the copy and paste function and the *Graphics – Ungroup* functions. When you ungroup a label you can change the text and adjust the size of the callout box and then regroup for a scaleable label.

- You can adjust the way legends look by going to *Graphics – Simplify*. This breaks up your legend into separate parts. You can delete or move the elements you are interested in and then regroup them. Remember though , that once you simplify your legend you will no longer have a live link with your View. If you change a color or a theme name in your View it will not show up on your Layout.

- Use neatlines in your maps. Neatlines are outlines around map object such as the View and legend.

- Scale bars can be very frustrating in ArcView. One way to keep scale bars under control once you have added them is to adjust the size by dragging with the mouse. The other way it to delete the scale bar and start again.

Printing Issues With ArcView

It is a very good idea to invest in the ArcPress for ArcView extension if you have a plotter. Without this extension you have to rely on your printers memory to plot your maps. Most printers do not have enough memory to deal with the complex graphics contained in most maps. What ArcPress does is "rasterize" your map. What this means is that it creates a graphic image of your map and sends it to your plotter in discrete "chunks". This allows you to use the memory of your computer instead of the memory of your plotter.

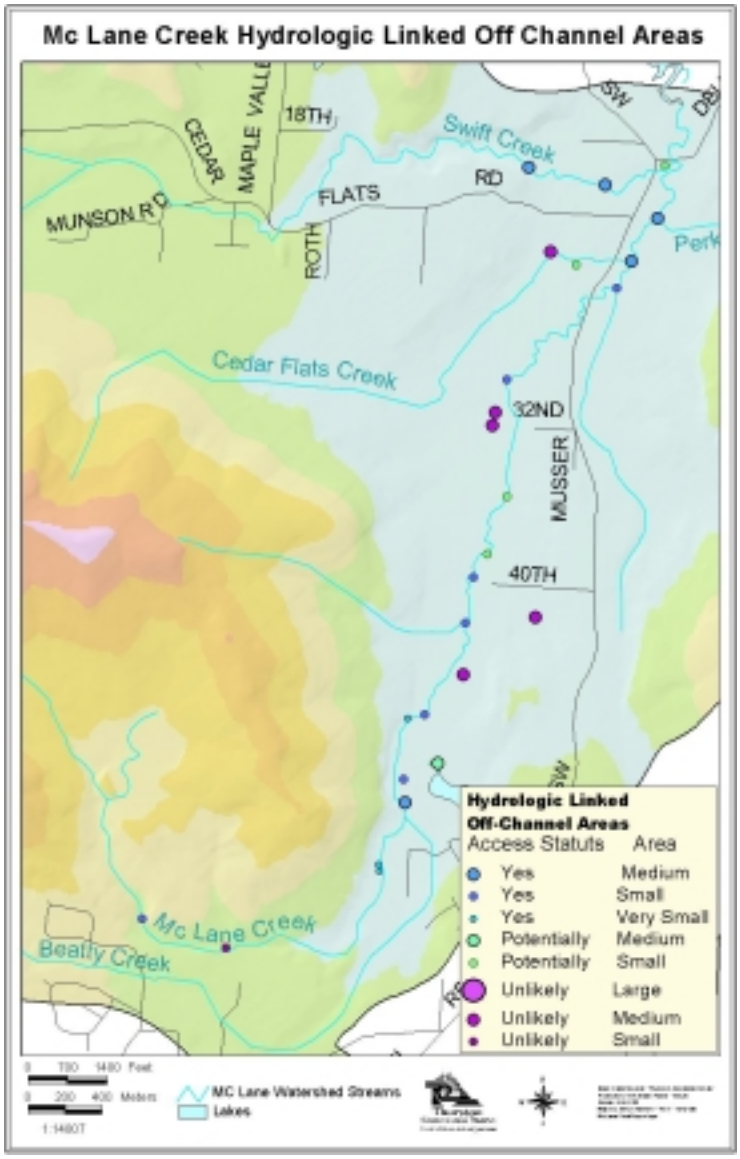
Preparing Maps for Reports

In ArcView you can export your layout to an image file such as a JPEG or Bitmap. To use this function go to **File – Extensions** and check on "JPEG ImageSupport". Make your layout active in your View then go to **File – Export**. Here you can choose an image file format and specify where you would like the image stored. To insert the map in a Word or Excel document merely choose **Insert – Picture –From File.**

Bivariate Legend

A bivariate legend is a legend that shows two different aspects of the same theme. Figure 5.4 shows a map that uses a bivariate legend. In this case, the legend shows access status and size of area. The access status is differentiated by color and the area or size is differentiated by the size of the symbol.

Presently, there are 2 scripts for making bivariate legends available on the ESRI arcsripts page. Try them both to decide which one works best for you.


Mc Lane Creek Hydrologic Linked Off Channel Areas
18TH
Swift Creek
RD
MUNSON RD
FLATS
ROTH
Cedar Flats Creek
32ND
MUSSER
40TH
Mc Lane Creek
Beatty Creek
Hydrologic Linked
Off-Channel Areas
Access Statuts Area
Yes Medium
Yes Small
Yes Very Small
Potentially Medium
Potentially Small
Unlikely Large
Unlikely Medium
Unlikely Small
MC Lane Watershed Streams
Lakes
Figure 5.4

6.0 Raster Data and Spatial Analyst

What you will learn:

- Downloading and importing DEMs
- Introduction to Spatial Analyst
- Advanced analysis tools
- Spatial Tools extension

Thanks goes to Michael Wandler of Central Washington University, Ellensburg, WA for doing the research, development, and design of most of section 6.

In ArcView, there are two types of data: vector and raster. Vector data is point, line, and polygon, whereas raster data is in a grid format. Until now, you have worked exclusively with vector data. To expand your ArcView capabilities, this section will introduce raster data, explain what it is and how it is used, and show various methods of management and manipulation.

Understanding Raster Data:

Many features of the real world can be easily represented with vector data. For instance, mailboxes can be represented as points, roads can be represented as lines, and large buildings can be represented as polygons. But these are all finite features; they all have easily distinguishable boundaries. What happens when you are dealing with real world data that does not have strict borders or easily quantifiable values, such as precipitation or elevation, but, instead, occur in highly variable amounts everywhere?

The answer is to create a grid, where each cell represents the average value for the area that cell covers. For instance, you could create a grid that is ten kilometers by ten kilometers and is constituted of cells that are ten meters on each side. Inside each of these cells, there is going to be an average amount of precipitation, elevation, or slope (e.g., 10.2 centimeters, 654 meters, or 8.3^{o}), and that value will come to represent the cell in the database. When all of these cells are then observed together, they give a good, although far from perfect, representation of the data for the area.

DEMs (Digital Elevation Models)

One of the most helpful types of raster data are **DEMs (Digital Elevation Models).** These DEMs come in the size of a 7.5-minute quadrangle with cell sizes of 30- or 10-meters and are available to download free from the Internet. Once the DEMs have been imported into ArcView, as well as providing information about the elevation of specific areas, they can be used to derive slope and aspect or create contour lines. You will go through this process one step at a time.

EXERCISE 1 Downloading DEMs and Importing Them into ArcView

The USGS has two options for acquiring 1:24,000-Scale (7.5-minute) Digital Elevation Model data. GIS Data Depot or Map Mart. These instructions are for using GIS Data Depot web site.

1. Go to USGS web site http://edc.usgs.gov/doc/edchome/ndcdb/ndcdb.html . The original DEM 7.5 minute tiled data available only in Spatial Data Transfer Standard (SDTS) form is available at no cost via downloads from the GeoComm International Corporation at http://gisdatadepot.com/dem

Click the link to GIS Data Depot web site (above). Bookmark the FAQ page. It will come in handy! From here go to DOWNLOAD DEM DATA HERE link . Click Washington State. Select the county you want. Go to Digital Elevation Models (DEM) - 24K and download what you want. Follow download instructions. The data is in a *.tar.gz format.

2. At this point you will need to make a new folder (no spaces) where you will put the downloaded data. This zipped file has .ddf files which represent a "SDTS transfer" (explained later) Unzip it and uncompress it. * Unzip each transfer file in its own directory because the file names are different for each DEM.

3. Download **sdts2dem**: a translator for STDS DEM files. http://www.cs.arizona.edu/topovista/sdts2dem.html.

* Make sure you get version 0.017: Oct 3, 2001

Follow the instructions at this site for running the program.

When you open the file, a DOS window will come up. Follow the instructions.

The 4 numbers are in the .ddf file names

The name of the output file will be placed in the same folder as the .ddf files

Type L0 (L-zero) not L-number O for the last question.

The translator process will run quickly, then you can import the DEM into ArcView.

Data Management Notes:

1. Observe the default name of the file (e.g., h546120) after the download, but do NOT change the name yet. You can rename it when you import it into ArcView as a grid. Keep the original code name of the original DEM in your records if you need to refer to it later.
2. Have a naming convention and separate folders for
    1. zipped files
    2. unzipped files
    3. grid files
3. The files will NOT work properly if there are any spaces or foreign characters (‘, “, -, #) in the *folder* names (e.g., G I S, Temp Docs) of the absolute path to where the quads are being saved or in the quad name itself (e.g., South Ellensburg). An underscore (e.g., South_Ellensburg) is okay. (This is a naming convention that was created by ESRI so that Arc products would function properly on UNIX machines.)

4. Importing into ArcView:

At this point the DEM will be in “raw data” format which is unreadable in ArcView. ArcView will import the file and convert it to a Grid file which can be used for analysis.

A. Open a new Project and View. Save the project immediately as “proj6”. Then turn on the Spatial Analyst extension (found in “Extensions” under the “File” menu).

Note: If Spatial Analyst is turned on *before* the project is saved, it will NOT register properly and the import will NOT work. This is one of those tips that pays off to know.

B. Under the **File** menu select “Import Data Source”. Then select “USGS DEM” as the file type as shown in figure 6.1. Click “OK”.

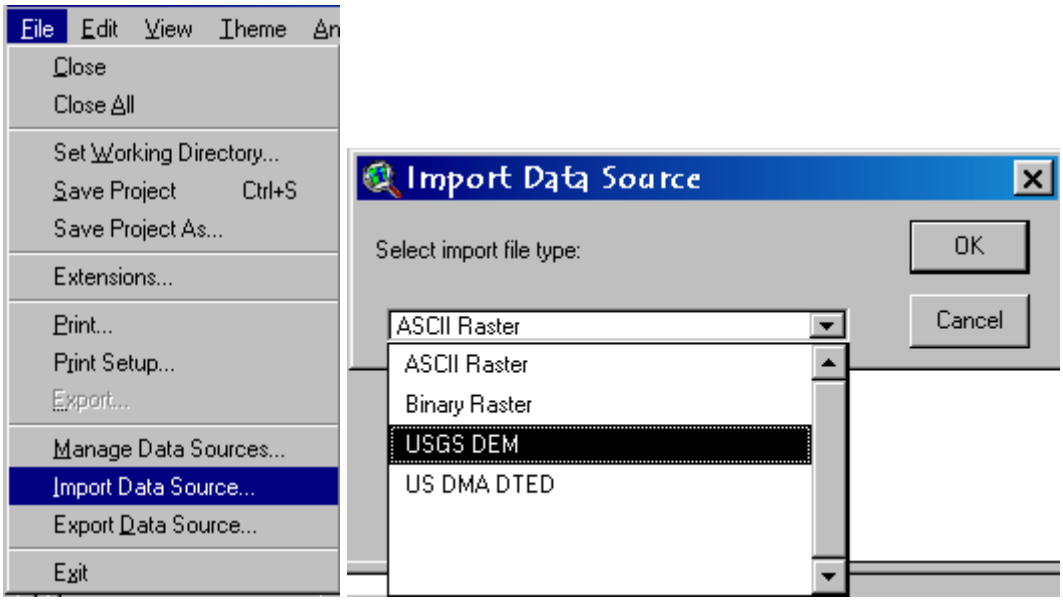


Figure 6.1

C. Navigate to **C:\unzipDEM** folder and double click on it. Now select the unzipped DEM. You will get a dialog box that says "imgrd1". Now it is a good idea to rename the file to something familiar, e.g., "eburgsouth" and put it in the folder called "gridDEM".
D. Click on the "YES" button when asked if you want to "Add grid as theme to the view?"
E. It will look like the following in figure 6.2:

Data Management Note: Once you have imported a DEM, you will be able to access the file by going to "Add data" and navigating to where you saved the imported grid (i.e., **C:\DEMgrids**). You must have the "Data source type" set to "grid data source".

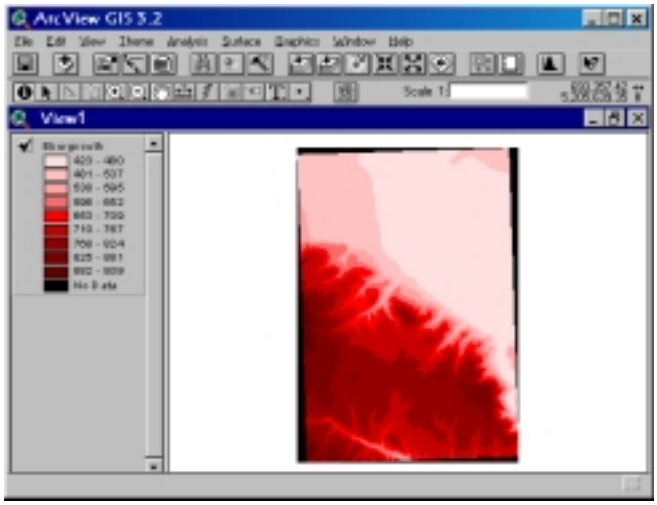


Figure 6.2

6.1 Introduction to the Spatial Analyst Extension

Spatial Analyst is the extension used for manipulating, managing, and querying **raster** (grid) data. In this section, you will take a look at some of the basic techniques and capabilities associated with this extension.

In addition to importing raster data, there are many ways to create new layers of raster data from both vector and other raster data. The processes you will explore are:

- Hillshade, Slope, Aspect, Find Distance, Map Query and Viewsheds;
- Creating Contours;
- Interpolation and Map Calculation;
- Proximity Analysis, Convert to Grid, and using the MASK feature

When you turn on the Spatial Analyst extension two menus will be added: **Analysis** and **Surface** (figure 6.3).

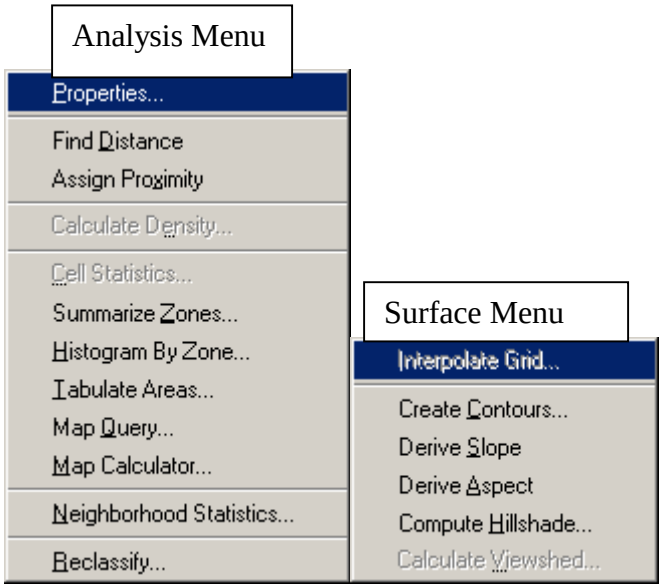


Figure 6.3

The analysis menu items help to determine suitability models for best case/worst case situations, like best salmon habitat, given certain conditions or bad areas for salmon spawning because of habitat degradation.

The surface menu items allow you to retrieve additional data from grids like elevation, slope and aspect from DEMs also used in analysis.

EXERCISE 2 Surface Analysis for Suitable Site

You are helping a landowner with a farm plan. The landowner has asked you to find a suitable building site for a barn on her property in the McLane Creek watershed. You went to the site and talked to her to determine the following criteria :

1. Elevation is greater than 300 feet and less than 600 feet.
2. Building must be on a slope less than 10 degrees.
3. Building must be within 1000 feet of a road.
4. The building must be in a partially north facing location in order to be protected from southerly storms.
5. The landowners want to preserve their existing view.

1. Make a new View in "proj6" and add "McLaneGrid" to the View

You will begin with computing a hillshade:

A. Name the View "Suitable Site". (Spatial Analyst should be on). Set "Map Units" and "Distance Units" to "feet" in View Properties. Navigate to specified location of "McLaneGrid" (make sure file type is set to "Grid Data Source"). Turn on the Grid.

B. Go to **Surface** menu, select **Compute Hillshade**.

C. The "Compute Hillshade" dialog comes up and asks you to input the azimuth (sun direction) and [sun] altitude (figure 6.4). Accept the default settings of 315 and 45. Click OK.

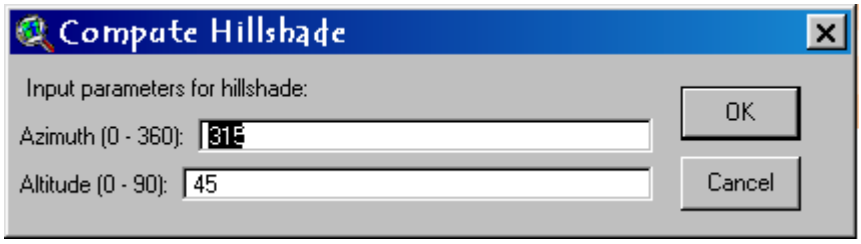


Figure 6.4

D. In the TOC to the left, the "Hillshade of McLaneGrid" appears. Turn it on.

E. Change the brightness by going into the Legend Editor. Click "Advanced" button at the bottom. Under the "Brightness Theme" drop down menu, select "Hillshade

of McLaneGrid" and click OK. Change the maximum cell brightness to 100% because anything less unnecessarily reduces cell contrast.

F. Change the color ramp to "Elevation 2".

G. Save the Data Set and name it "mclanegrdhlshd". (See "Data Management Note" below).

Data Management Note: When you create a hillshade, aspect, slope, etc., from a pre-existing grid, you will notice that you are not prompted to save the new grid. Instead, these grids are given a generic name (e.g., slope1, surface4) and placed in your working directory (e.g., c:\temp). If you make multiple grids of the same type, it is very difficult to keep track of them. Fortunately, there is a way to save them with a more explicit name.

Make the grid theme active that you want to save and then click on "Save Data Set" under the "Theme" menu. The "Save Data Set" dialog will appear with the default name and directory for the grid. Navigate to the place you want the grid and save it under a more expressive name (e.g., distmclane, slpmclane).

If you do not rename the grid BEFORE you save the Project, you will not be able to use the "Save Data Set" option. You will instead use **Manage Data Sources** under the **File** menu. In Spatial Analyst this is the ONLY way to copy, rename of delete grids. DO NOT do this in Explorer or My Computer! Choose "Grid Data Source". You must make sure that the grid is NOT in use when you do this, however. Also, these changes won't reflect in the apr, so you will receive "Where is" questions if you rename or move the data using this method.

2. Derive the Slope

Now that you have a viable background for your eventual findings, you will begin the analysis. As you already have the DEM to find the requested elevations, you will start with deriving slope.

A. Make sure the original "McLaneGrid" grid is active. Go to **Surface** menu, choose **Derive Slope**.

B. A new grid, "Slope of McLaneGrid", appears in the TOC.

C. Turn the new grid on and inspect it. These findings show the degree of slope between each cell. It is possible to also find the percent slope through Map Calculator (discussed later.)

4. Derive the Aspect to Determine North Facing Slopes

You now have a grid with slope values that can be queried to isolate all of the areas with fewer than 10 degrees of slope. The next step is to derive aspect, which creates a grid where each cell is characterized by the direction it faces. The values are divided into 360 degrees.

A. Make sure the original "McLaneGrid" grid is active. Go to **Surface** menu, choose **Derive Aspect**.

B. A new grid, "Aspect of McLaneGrid", appears in the TOC.

C. Turn the new grid on and inspect it. You will notice that the color scheme does not make it particularly meaningful to humans. As you are going to query this grid eventually, its appearance at this point is irrelevant.

5. Find the Distance to the Access Road

Three of the four conditions can now be found, leaving only the distance from the road as a factor. We will use the "Find Distance" analysis tool to determine distance buffers.

A. Add the Theme, "mclaneroads.shp" from the specified folder. Make sure it is the active Theme and turn it on. Go to **Analysis** menu, choose the **Find Distance** option (figure 6.5). Set the Output Grid Extent to "Same as Mclngrd" and leave the Output Grid Cell Size to "As Specified Below". Click OK.

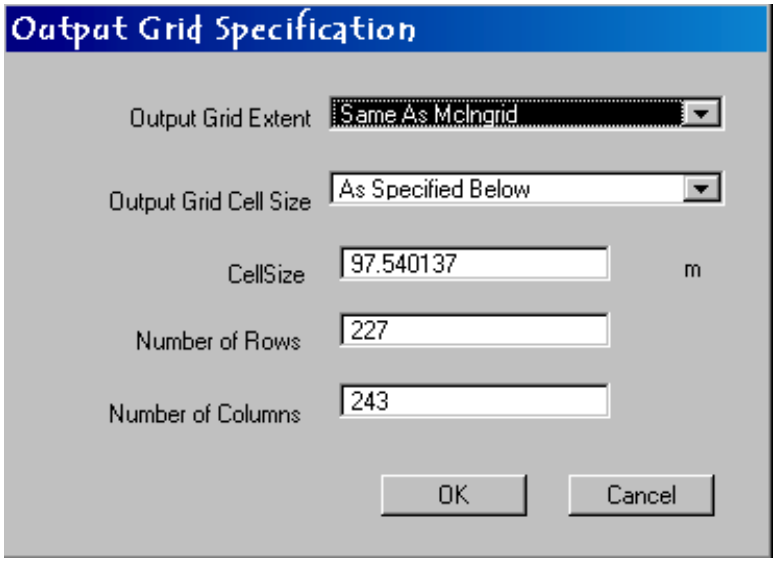


Figure 6.5

B. The values will be in meters. Change the values to feet by using Map Calc. Go to **Analysis** menu, **Map Calculator** and type in the following expression:

([Distance to Mclanroads.shp] / 3.28) Click "Evaluate". A new grid called "MapCalculation1" will appear with the values in feet. Go to **Theme** menu, **Save Data Set** and change the name to "distomclrds". (You will be using this grid later).

You now have the four layers necessary for analysis of the areas that meet your landowner's request.

6. Determine the Probable Areas for the Building Site Based on the 4 Conditions, Using Map Query

A. Under the **Analysis** menu, choose **Map Query** and specify the elevation, slope, distance, and aspect as shown in Figure 6.7. Remember to click on field values and operators (+,-,>,<, and, etc). Don't type them in because you are prone to getting syntax errors. You can type in field values to get exact numbers though.

Map Query Note: Don't forget your Boolean logic when constructing the full expression. Using "and" as your connector requires all of the individual arguments to be fulfilled, whereas using "or" to connect arguments allows for a selection of ALL areas that meet ANY of the criteria.

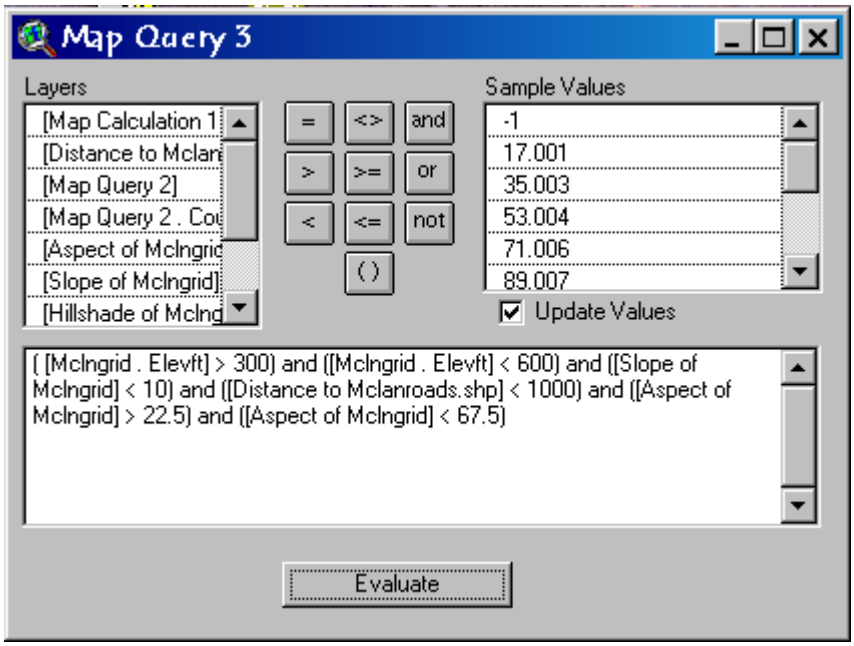


Figure 6.7

"Map Query 1" appears at the top of the TOC with areas that meet all four of the requirements shown in red as seen in Figure 6.8

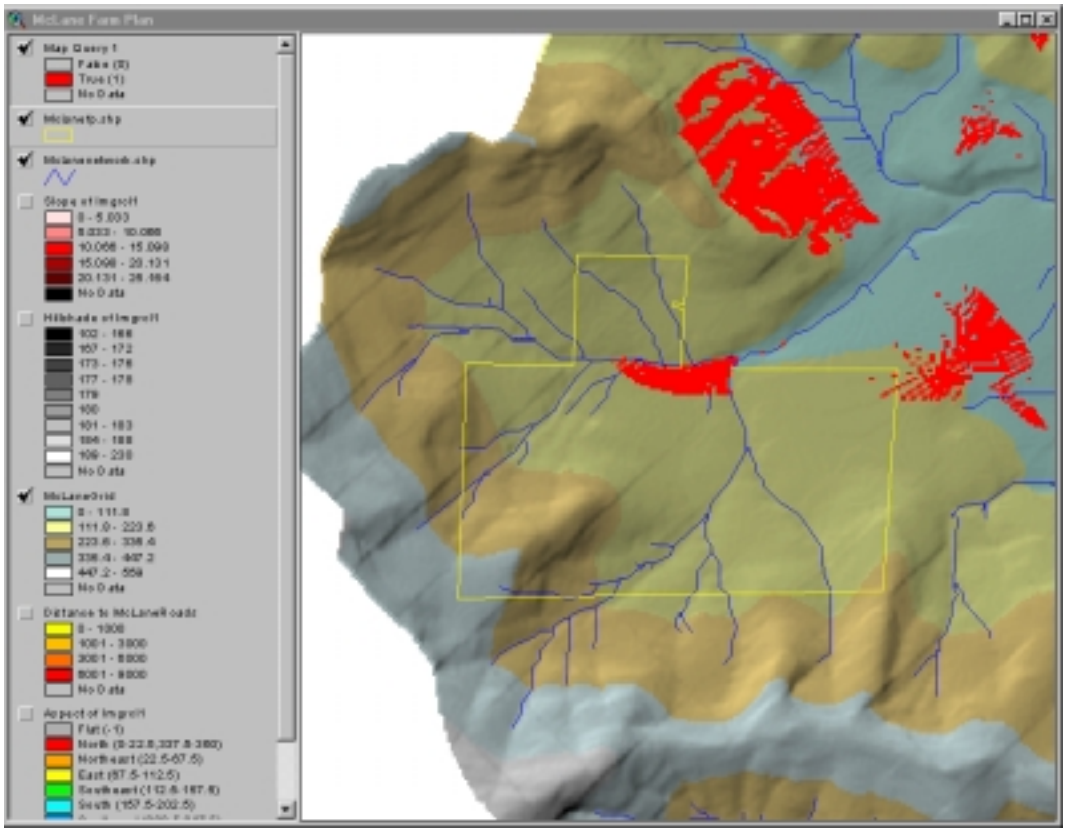


Figure 6.8

As you can see, there is a small area in the northern part of the property that meets the needs of the landowner. The final condition is determining the view from this site.

7. Create a Viewshed from the Potential Site.

A. Make a new point Theme and call it “site.shp”.

B. Place the “site.shp” within the suitable area on their property. Stop editing.

C. Now make BOTH the McLaneGrid Theme and site.shp active.

D. Go to **Surface** menu and select **Calculate Viewshed**. If “Calculate Viewshed” cannot be selected, make sure you followed step C carefully. If you get an error message, you are still in edit mode.

E. “Visibility of site.shp” is placed at the top of the TOC. Turn it on. The green colors are representative of those you can see from your selected spot. The red colors represent the areas you can’t see. Make the red transparent and overlay the green on the area (figure 6.9). Adjust the layers in the TOC so you can see the property boundary and site location.

The landowner will be very happy. Now that she can get quick results with GIS she would like to explore the idea of a ski resort! Her new requests will be slopes over 40%, north-facing aspect, and elevation of greater than 4,000 feet. (Not in this neck of the woods!)

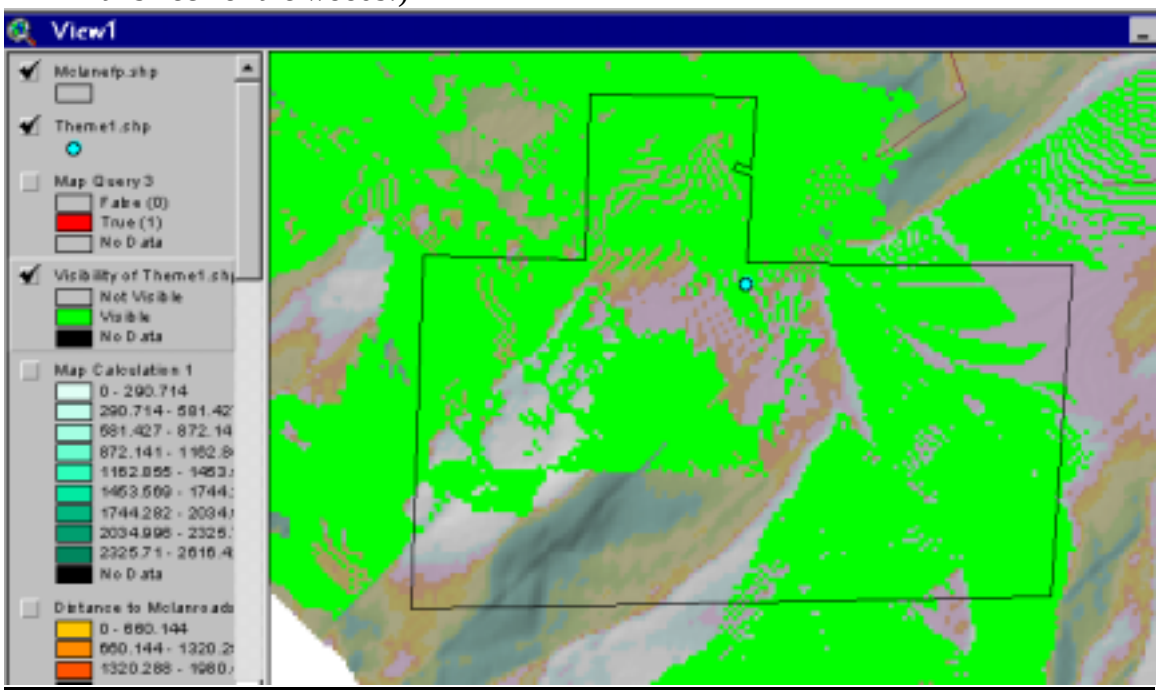


Figure 6.9

8. Deriving 10 foot Contours

Finally, for the engineer, it would be useful to have contours of the area, better than 40 foot intervals (standard on quad maps). It is easy to derive contours from DEMs of 10 feet or less.

A. Make a new View and call it "Contours". Make "McLaneGrid" the active Theme. Go to **Surface** menu, **Create Contours**. Set contour interval to "10" and base contour to "0". (If you want smoother lines, set the base contour to ".5"). "Contours of McLaneGrid" are added to the TOC.

B. Open the table and start editing. The field "Contour" is in meters. Convert it to feet by adding a field called "Feet". Make sure the new field is active. Go to the "Field" menu and click "Calculate". Give the following expression: [Contour] * 3.28

C. Now you can label the elevations of the project area. Zoom into an area that's easy to label. Set the font size to "6". Set label properties under the Theme menu. Choose "feet" for the field and click the feature.

D. Save changes to the Project.

> **Note:** Autolabel is not useful when labeling contour lines.

6.2 Interpolation and Map Calculator

What is the process of Interpolation?

Interpolation is the process of filling in the blanks with a given set of data. To understand the process, attempt to visualize the most basic scenario for which interpolation could be used. If you had two point samples, a mile apart, one representing seven units (point A) and another representing eight units (point B), and someone asked you, "Directly between these two points, how many units would you guess existed?" a good guess would be 7.5. This, in essence, is interpolation. It is a process that uses existing data points to make educated and guided guesses about the values able to be found in surrounding areas.

Most interpolations are much more complex than two sample points. It would be easy for you to create a line of values between points A and B running from seven to eight. Once a third point is introduced and assumed to influence the first two, the equation becomes much more complex, however. When you have 20, 50 or 1000 points, the equations become almost impossible to do by hand. This is the value of interpolation in Spatial Analyst.

EXERCISE 3 Interpolating Gas Prices & Using Map Calculator

1. Working with gas prices

You have been contracted to do a study on gas prices in Ellensburg. You are given the September 1999 and September 2000 prices per gallon of gas for all service stations operating during both of these times. You are to provide a map showing average price of gas per area as well as the rate of increase in price over the past year. By interpolating the data, the cell values in the output grid Theme are best estimates or interpolated values. Certain assumptions are made when making these estimates.

A. Close the Contour View and make a new View called "Interpolation".
B. Add the following Themes:
   eburgroads.shp
   gasstations99.shp
   gasstations00.shp

The roads will be used as a guide for where the gas stations are located and to set various extents when interpolating. The other two shapefiles have 20 fictitious gas stations located in Ellensburg. Each has a list of associated prices for a gallon of gas in either 1999 or 2000. (These are not realistic gas prices).

2. Interpolate prices for 1999

A. Make the "gasstations99.shp" Theme active and go to **Surface** menu, **Interpolate Grid.**

B. Specify the output grid to be "Same as eburgroads.shp" (figure 6.10). The other defaults are fine. Click OK.

C. The "Interpolate Surface" dialog now appears. There are two different methods of interpolation: IDW (Inverse Distance Weighting) and Spline. We will use IDW.

D. The "Z Value Field" is where you select the field in your Theme that you want the values for interpolation to come from. Select "Prices1999". The rest of the defaults are fine (figure 6.11). Click OK.

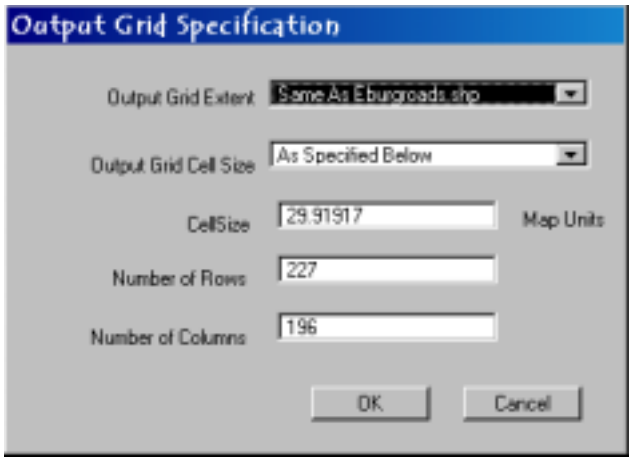


Figure 6.10

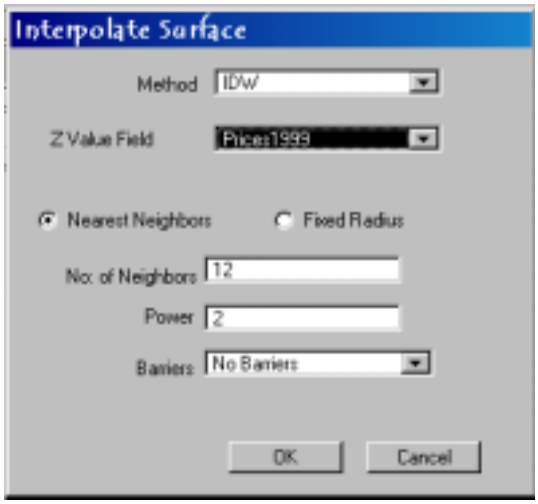


Figure 6.11

E. “Surface from Gas Stations 1999” appears at the top of the TOC. Go to**Theme** menu, **Properties** and change the name to “Prices 1999”.

F. Now turn on the interpolation and look at the distribution of prices. Move eburgroads.shp and gasstations99.shp to the top of the TOC. You will notice that the higher prices occur closer to Interstate-90, as one would assume (figure 6.12). Also feel free to look at the table for “gasstations99.shp” and compare the price range with the range for interpolation.

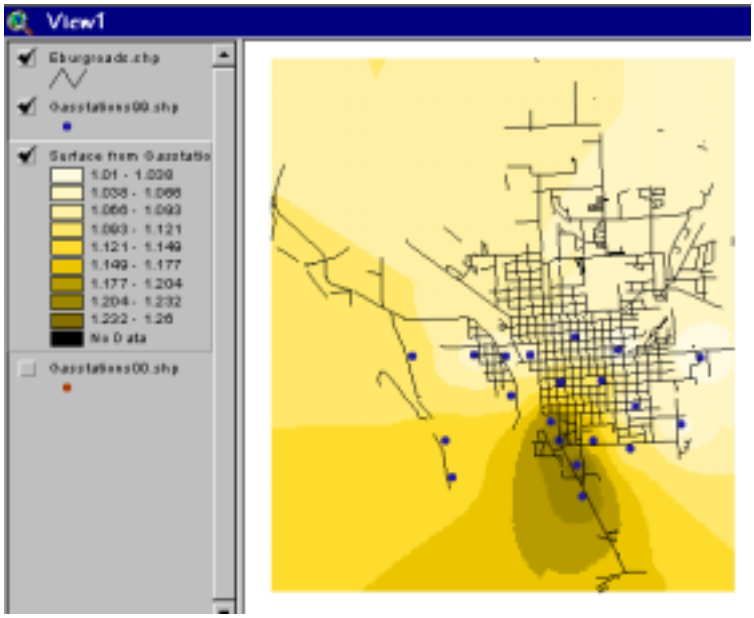


Figure 6.12

G. If you were now asked where to buy property for a new gas station, based solely on the price the station could charge for a gallon of gas, you would have a good guide. Likewise, if you were shown a 21st gas station somewhere in the city limits, you would be able to predict how much a gallon of gas would cost there with high accuracy. These are two of the many uses of interpolation.

Note: There are a number of options available when you are setting an interpolation. Besides two different methods (spline and IDW) there are two additional methods that you can access by using Map Calculator. Each of these methods come with a number of settings, allowing you to manipulate the number of neighbors, how much influence each neighbor has, the ability to set barriers, et cetera.

The reason for this is that different data sets behave in different ways. In the example in the note above, the assumption is that points A and B are representative of the average values for the entire area and that these values are ubiquitous. If you were to interpolate population with this same method, the results would be highly erroneous. By taking the population of Yakima (~60,000) and Ellensburg (~13,000), it would be incorrect to assume there is a city with a population of about 36,500 people directly between the two.

The different methods of interpolation and the settings for each allow you the capability of best suiting the trend of dissemination based on the values you have.

3. Interpolate prices for 2000

A. Make "gasstations00.shp" active and go to **Surface** menu, **Interpolate Grid.**

B. Specify the output grid to be "Same as eburgroads.shp". The other defaults are fine. Click OK.

C. The "Interpolate Surface" dialog now appears. We will again use IDW again.

D. In the "Z Value Field" select "Prices2000". Click OK.

E. "Surface from Gas Stations 2000" appears at the top of the TOC. Again, change this to "Prices 2000".

F. Drag "gasstations00.shp" and "eburgroads.shp" to the top of the TOC and turn on the interpolation. The distribution looks very similar. The same gas stations that had the highest prices before still have the highest prices. But it would be nice to be able to see the exact differences.

The last portion of the contract was to create a map showing the percent change for the area. You will do this with Map Calculator.

Using Map Calculator:

A. Under the **Analysis** menu select **Map Calculator**.

B. In order to see the percent increase, you will need to divide the 2000 price surface by the 1999 price surface as shown in figure 6.13. However, as the price for 2000 includes the price of 1999 plus the increase, the resulting grid will show up as 1. and then the increase. To get just the percent change click on "-" and then type

"1". All that is left is to multiply the equation by 100 to get a true percentage (figure 6.13).

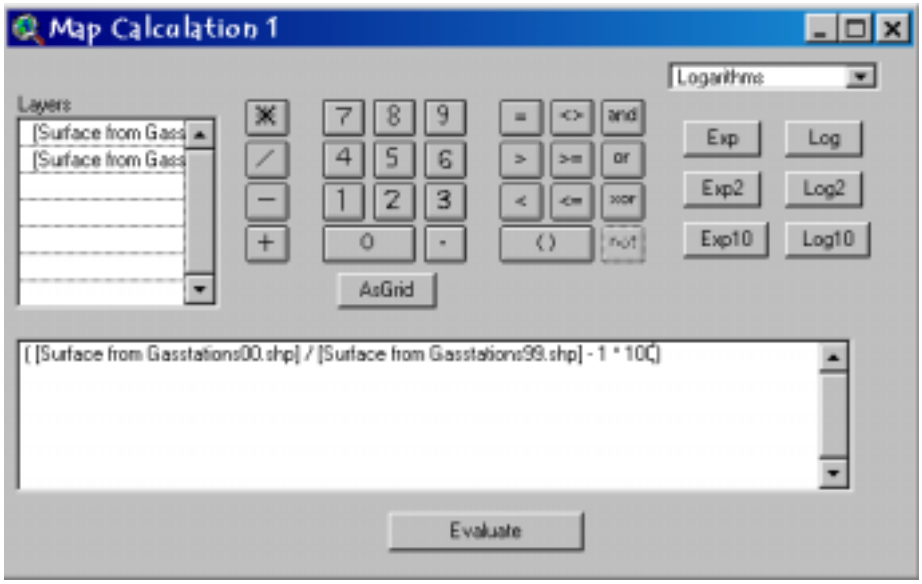


Figure 6.13

C. "Map Calculation 1" appears in the top of the TOC. Change the Theme name to "Percent Increase".

D. Turn on "Percent Increase" and analyze the results (figure 6.14). You will discover that the gas stations having the highest price per gallon originally, actually increased their prices to a much smaller percentage than those that had less expensive gas to begin with. The most expensive gas stations are now a better deal than they were a year ago. So if you were asked why the average distance driven for gas per person in Ellensburg has decreased from the past year, you would have a map to support the idea that people are no longer saving as much money to drive across town and, hence, are less willing to do so.

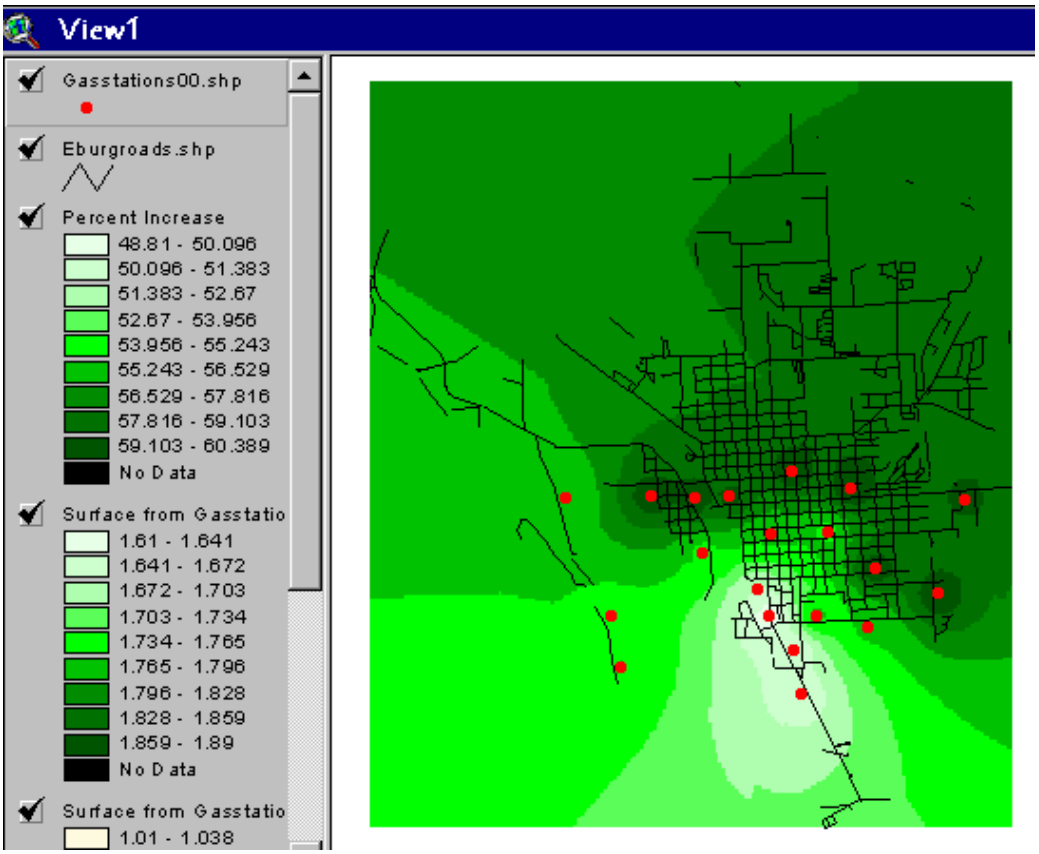


Figure 6.14

6.3 Proximity Analysis

Proximity analysis sets the value of each cell to the ID or selected field value of the nearest feature. In other words, each cell is assigned to the source it is nearest to. The result is like a distance buffer. Point, line and polygon cells can be used as input features. Proximity grids can be used to determine the area of space allocated to each feature of the closest feature in another Theme.

EXERCISE 4 Proximity Analysis

Your brother-in-law has just gotten a position at the world-renown Victor Hugo Zoo and Aquarium. You are just happy he has found work.

After about a month of working there, he calls you early one morning to ask for help. He tells you that they have a gigantic bird exhibit, but that they want to know how well each of the five birds will do. Apparently, the birds are fiercely territorial. Their hunting areas

have borders exactly between nest sites. Furthermore, the birds with the most coniferous trees in their area seem to thrive.

You tell him you will do your best and go back to sleep.

1. Assessing Bird Health Using Proximity Analysis

A. Make a new View and call it "Bird Health".

B. Add the following Themes:
Birds.shp
Vegetation.shp
Fence.shp

C. You know that the birds' territories are split exactly between each of the nests. Make sure the "birds.shp" is active. Go to **Analysis** menu, select **Assign Proximity.**

D. Set the "Output Grid Specification" to "Same as fence.shp" and click OK.

E. Choose "Bird_Name" for your field and click OK.

F. "Proximity to Bird Nests" now appears in the top of the TOC. Move "Bird Nests" above "Proximity…" and then turn "Proximity…" on as in Figure 5.5.

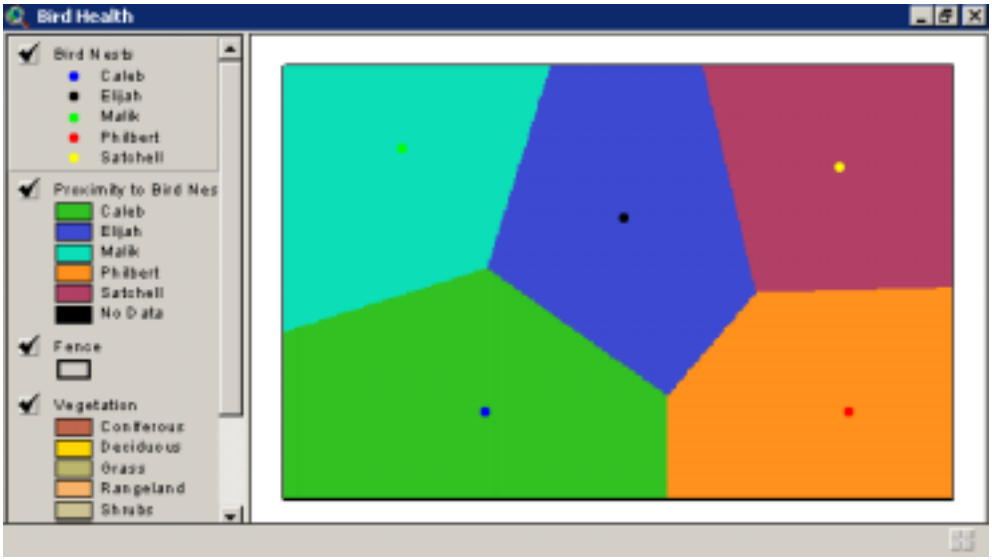
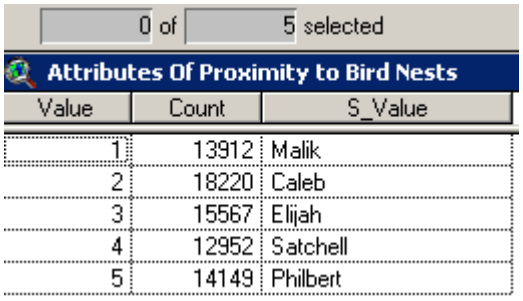


Figure 6.15

G. As you can see, proximity deciphers which areas are the closest to which nests (figure 6.15). So all of the grid cells in Caleb's area, for instance, are closest to his nest than any other nest.

H. Open “Proximity to Bird Nests” Theme Table (figure 6.16). You will notice that to the left of each name is a count of the cells in that bird’s area. Arrange the number of cells in descending order. You can now tell your brother-in-law that Caleb has the biggest area, followed by Elijah, Philbert, Malik, and Satchell. Based only on this information, it is likely that Caleb with thrive while Satchell will fair poorly.



Value	Count	S_Value
1	13912	Malik
2	18220	Caleb
3	15567	Elijah
4	12952	Satchell
5	14149	Philbert

Figure 6.16

I. The second qualification for bird health is total amount of deciduous trees in their area. Perhaps Satchell will do better in this category.

2. Using Convert to Grid to Determine Coniferous Trees in the Area

A. Turn off “Proximity to birds.shp” and “birds.shp”. Make the “vegetation.shp” Theme active and turn it on. This Theme gives you all of the different vegetation types inside the fence boundary. You need to get a count on just the coniferous areas.

B. Click on the Query Builder button and and type the following expression: “Veg_Type = Coniferous”. Click New Set. All of the coniferous areas are now selected and can be converted into a grid.

C. Under the **Theme** menu select **Convert to Grid**. Only the selected areas will be converted to grid.

D. Save the new grid as “Veggrid”.

E. In the “Conversion Extent” dialog, set the “Output Grid Extent” to “Same as Fence”. The rest of the defaults are fine so click OK.

F. The “Conversion Field” dialog now comes up. This is a very important step that might not make immediate sense. In essence, ArcView is going to replace the vegetation polygons with cells. These cells need to be told which values to take from the polygons. So if you choose “Id” for instance, any cells created to represent the polygons with “Id” equal to “1” will take the value of “1”. For this exercise, select “Veg_Type” and click OK.

G. An “Attribute Join” dialog appears. This gives you the opportunity to import your entire theme table into the grid theme you are creating or just leave the table with the single value you selected in the last step. If you click on the “Yes” button, the grid will look at the data you asked to bring over (i.e., Veg_Type) and associate all of the other values. So, if the “veg_type” is “grass”, and “grass” also has an “Id” of “1” and a “Code” of “987”, then those things come over in the table for the new grid. If you choose “No”, then ONLY “veg_type” will appear in the theme table for the new grid (along with the default cell count and value). Click on No.

H. When prompted to add the new grid click Yes (figure 6.17).

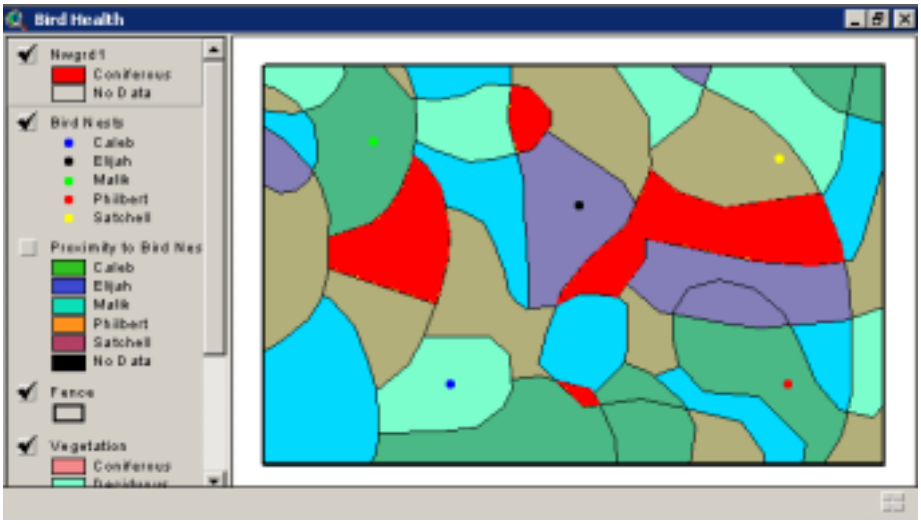


Figure 6.17

You now have a grid version of just the coniferous areas. But you still need to know the amount of coniferous trees inside each bird’s area.

3. Use the MASK Feature to Determine the Amount of Habitat in Each Bird’s Area

A. Go to **Analysis** menu and select **Properties**.

B. Near the bottom of the dialog that appears is the “Analysis Mask” drop down menu. Select “Veggrid” and click OK.

C. The term “mask” is somewhat misleading. By setting a mask, you are defining the area where ArcView will do analysis as long as that mask is in place. For this example, when further analysis is done, it will only be done in the areas represented by “Veggrid” (i.e., coniferous areas) because that is the mask that is set. Any non-coniferous areas will appear in Map Calculations or other grid analysis.

D. Under the **Analysis** menu choose **Map Calculator**. Double-click on "Proximity to Bird Nests.shp". (Do not select "Proximity to Bird Nests.shp. Count".) Click the "Evaluate" button.

E. It might seem odd that you simply select a single Theme and click "Evaluate". But remember, it is evaluating this theme ONLY in the areas where the mask is present. The resulting grid has a cell count for coniferous forest per bird area. Unfortunately, the bird names are not brought over in the new theme table. So you will need to do a join using "Value" as the common field.

F. Join "Attributes of Proximity to Birds.shp" with "Map Calc 1".

G. Your Theme Table is now complete (figure 6.18), and you can see that Elijah has the most coniferous forest in his region followed by Satchell, Malik, and Caleb (with a sufficient amount less, which should be noted). Poor Philbert doesn't have any coniferous forest in his area.

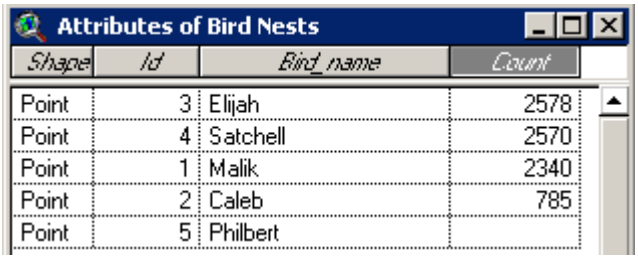


Figure 6.18

H. These tables could be used for further analysis with standard deviation on size taking into extent or a size to coniferous forest ratio calculated, but you don't have time. Instead you decide to create a nice map with tables representing area and coniferous forest and leave further decision making up to the animal experts.

6.4 Spatial Tools

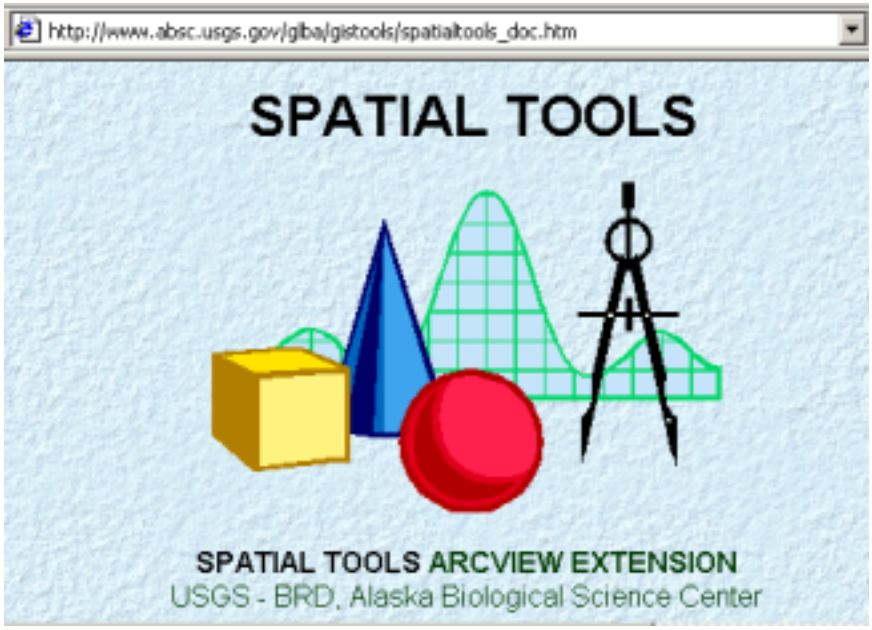


Figure 6.9

To find out all of the features of the Spatial Tools extension for Arc View Spatial Analyst, you can go to the address below.

www.absc.usgs.gov/glba/gistools/spatialtools_doc.htm

We will only be covering “Transformation” tools. Of those. “Set from View”-“Warp”, “Aggregate”, and “Grid to Image” will not be covered in this class. Nor will the “Clean Up” or “Analysis” tools be covered here.

EXERCISE 5 Spatial Tools

Go into ArcView and open “project6.apr”. (The extension will already be loaded).

Look at the “Transformation” menu . The following exercises will focus on “Merge Grid”, “Mosaic”, “Combine Grids”, and “Clip Grid”.

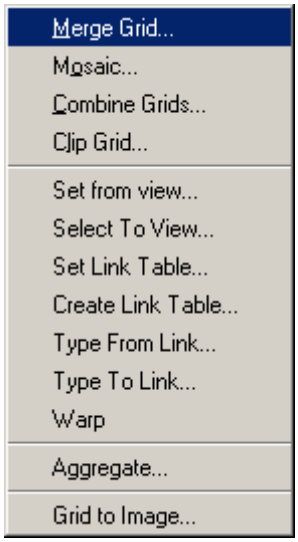


Figure 6.10

1. Merge Grid, Mosaic Grid, and Combine Grid

Both Merge Grid and Mosaic work well. They both serve to take two or more grids and merge them into a single grid. The difference between the two is in how they deal with overlap. Merge is based on priority, whereas Mosaic attempts to blend the cells using a mathematical process. The merge eliminates the space between the grids that was originally present when they were first imported. (see web site for additional information).

A. Make a new View called Spatial Tools and add the following grids:
   Eburgnorth
   Eburgsouth
   Eburg_utm.shp

   Make "Eburgsouth" the selected grid. Choose "Merge Grid" from the "Transformation" menu. Pick "Eburgnorth" as the grid to merge with the selected Theme.

B. Try "Mosaic" using the same themes. Notice the differences in the dialog and interface of "Mosaic" and "Merge Grid".

C. Try "Combine Grid", (you can only combine 3 or more grids) and notice the differences.

   The differences are slight, but may not be noticeable with the different methods.

2. Clip Grid

You can clip a grid with a **graphic** only. However, you can convert shapefiles into graphics and then use those. The "Clip Grid" function allows you to clip inside or outside of the graphic.

A. Make "eburg_utm.shp" the active Theme. Start editing. Using "Select Feature" tool, select ALL of the polygons in the Theme. Go to **Edit** menu, choose **Copy Features.** Then stop editing. You do not need to save your changes. Turn the shapefile off and go to **Edit** menu, choose **Paste.** Graphics should appear that mimic your shapefiles. If there are holes in the graphic and you want it to be one shape, go to Edit menu and "Combine Graphics". Make "Merged Grids of…" the active Theme, select the graphic (using the Pointer tool). Go to "Clip Grid", choose to clip "inside" and notice the results. Now go through the same process and clip "outside". You can change the "black" value to transparent or white (for solid).

Note:

1. If you have X-Tools, there is a capability under the menu for "Converting Shapes to Graphics." There are also other capabilities for changing graphics to shapefiles, points to lines and polygons, etc.
2. There is also a Clip Grid script on the ESRI site that doesn't clip null values.

7.0 Using Model Builder with Spatial Analyst

What you will learn:

- What the ModelBuilder is.
- How to use it.
- How to create a model using Property Sheets.
- How to create a model using a Wizard.
- Using ModelBuilder for a suitable site.

What is ModelBuilder?

ModelBuilder is a new tool in Spatial Analyst 2.0 that helps you create and easily manage a set of spatial processes in a geographic model (see **ModelBuilder Help** for more information). It's a flowchart of three components:

1. **Project (input) Data** –

   a. Themes created or not created from another ModelBuilder process. Project data is any shp or grid Theme accessed from the open Project

   b. DEMs can only be accessed directly from the hard drive or CD ROM drive.

2. **Functions –** Data Conversion (vector to grid, DEM to grid, interpolation), Terrain (slope, aspect, hillshade, contour), Buffer, Reclassification, and Overlay (weighted average or arithmetic)

3. **Output Data** – Derived Data Theme (ex., preferred area, stream buffer, high risk)

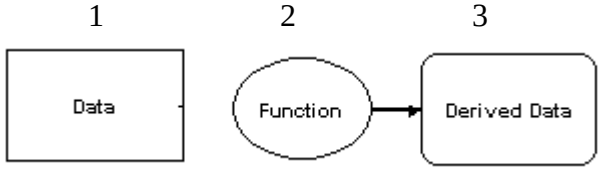


Figure 7.1

These processes can be connected to other processes to develop large models. You can also change properties of existing processes and rerun the model to see the changes, or delete/add processes.

How do you use the ModelBuilder?

ModelBuilder is accessed through the Extensions menu item. You access it by opening a Project or creating one, turning on the ModelBuilder extension, setting map and distance units, adding data to a View, and clicking **Model** menu and **Start ModelBuilder**. Keep in mind that you can only use data that is currently in the View.

Models can be developed by two methods:(both do the same thing – it's a matter of personal preference):

1. Buttons in the interface - drag-and-drop method (Figure 7.1 and 7.2). The result is unspecified components that must be specified through property sheets (defined later). The advantage is you can create a model before you are ready to specify particular datasets to use
2. A wizard accessed in the **Add Process** menu (Figure 7.3). The advantage is, ModelBuilder takes you through the entire process and makes sure all necessary information is in there.

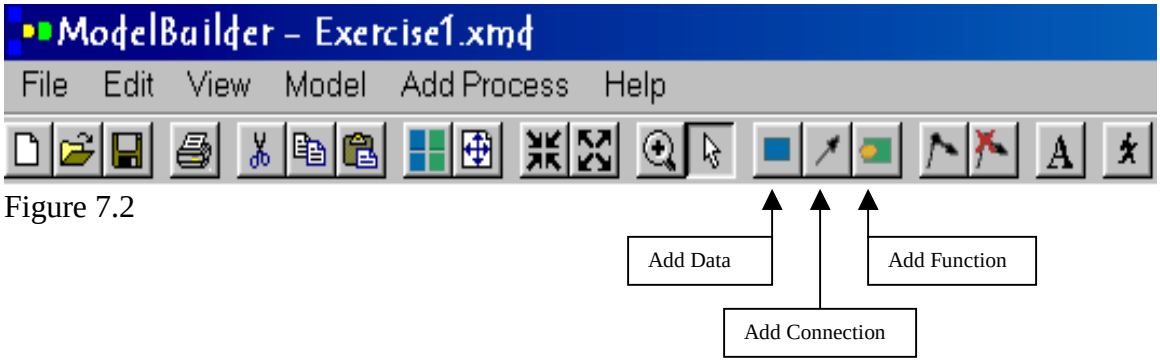


Figure 7.2

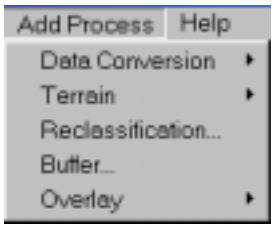


Figure 7.3

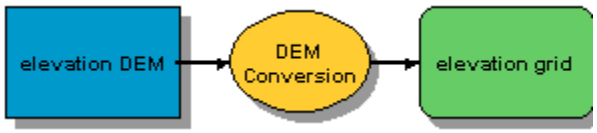


Figure 7.4

Note: The "nodes" or shapes in the Model window, are set to specific colors to indicate whether a process is complete or not. When the components are white it means that the data has not been completely defined or is unavailable in ModelBuilder. When the components are blue (project data), yellow (function), or green(output data) it means all necessary information has been set and it's accessible to ModelBuilder. The grey shadow means those parts of the model have been run successfully. (see graphics in Figure 7.1, and 7.4)

7.1 Creating a Model

There are two ways to create models using Model Builder: using the wizard or through the pull down menu. The next 2 exercises will teach you how to use both methods, then you can decide what works best for your situation.

EXERCISE 1 Creating a Model using the Wizard Method

1. Bring up the ModelBuilder window

A. Open a new Project and new View. Save the Project as "Proj7".

B. Open the View and turn on the ModelBuilder extension. Set map units to meters and distance units to feet.

C. Add the following Themes from the:
esri\av_gis30\avtutor\spatial\model\exercise1 folder.

studyarea.shp
vegetation.shp

D. Go to **Model** menu, **Start ModelBuilder**. The Model window comes up as blank window with a new interface. (Figure 7.5).

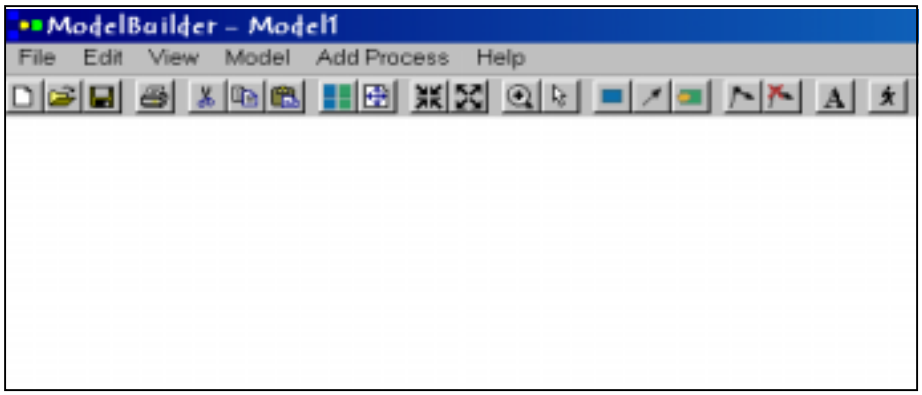


Figure 7.5

2. Convert a Vector to a Grid

A. Click **Add Process** menu, **Data Conversion -Vector to Grid**

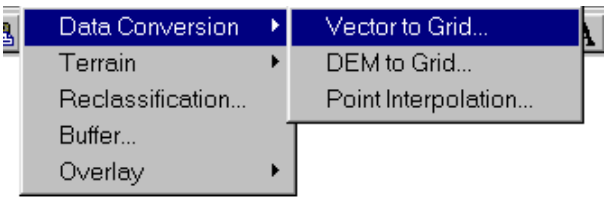


Figure 7.6

B. Follow the wizard (Figure 7.7) The input theme will be "vegetation.shp" and the input field will be "vegtype", click "Next". The classification table will stay the same, click "Next". The color ramp will stay the same, click "Next". The extent of the output theme will be "The extent of this theme" and choose "studyarea.shp", click "Next". The cell size will be "30", click "Next". Type in the following comments: "vegetation.shp was converted to veggrid, with vegtype as the attribute, click Next. The theme name will be "vegetation grid" and the file name will be "veggrid", Finish. The result is the process as shown in Figure 7.8.

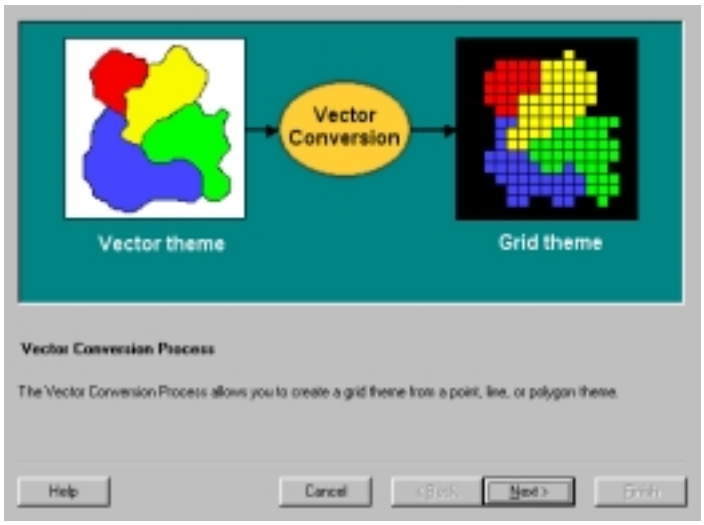


Figure 7.7

Figure 7.8

3. Run the Model

A. Click the "Run" button located at the far right. 
Before the model runs, the "Save Model As" dialog box comes up. You must create a new folder for your workspace. Notice as it says in Figure 7.9, the name of the new

folder will be the same as the model name you specify. Name the new folder "Exercise7_0".

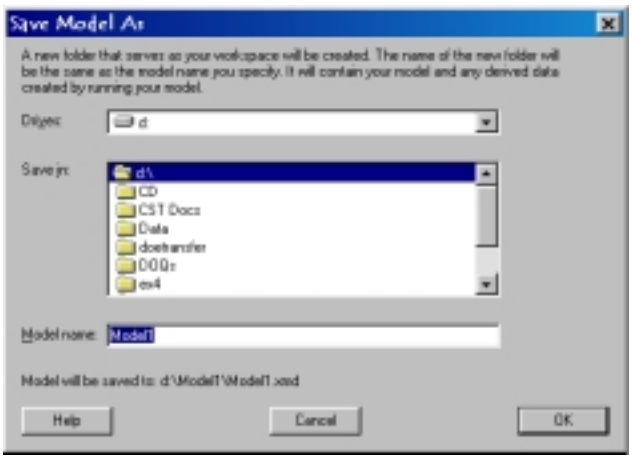


Figure 7.9

When you save a model, there are 5 files placed in the folder. Once you run the model, the newly created grid files are in the folder too (figure 7.10).

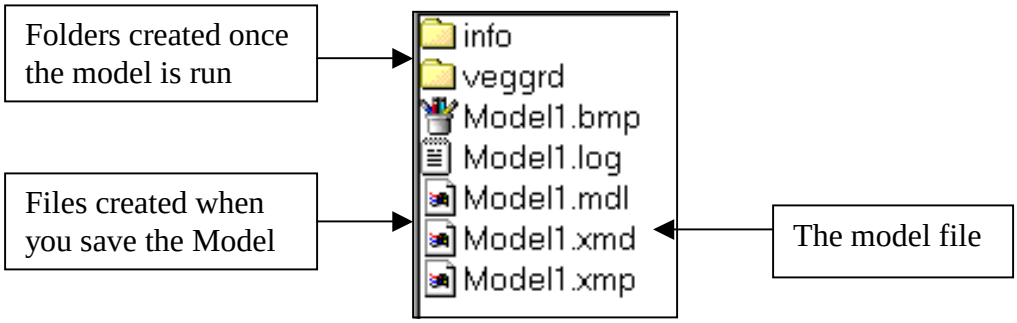


Figure 7.10

B. Look at the results of the model you just created and ran. Close the model.

EXERCISE 2 Creating a Model using the Drag-and-Drop Method & Property Sheets

---

1. Open a New Model

2. Add Project Data

A. Click the "Add Data" too, then click anywhere in the model window.

B. A node box with the word "Data" appears.

3. Add a Function

A. Click the "Function" tool, then click anywhere in the model window. 

B. Two nodes appear: "Function" and "Derived Data". These are always together. (Don't worry if the nodes aren't lined up. We will fix that soon).

4. Define Properties of the Project Data

A. Right click in the "Data" node. Select **Theme**. Now you can connect the processes.

B. Connect the processes using the "Add Connection" tool. 
Drag the arrow from "Theme" to "Function". Your Model should look something like that of figure 7.11.

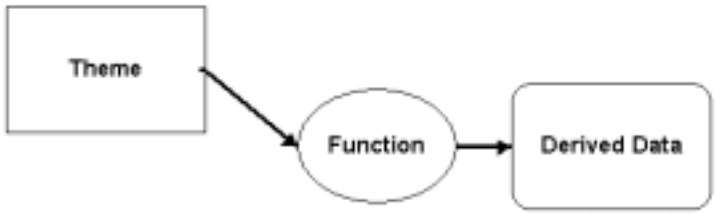


Figure 7.11

C. Align the nodes by clicking the "Auto Layout" button. 
It will automatically organize your model display as in Figure 7.12.

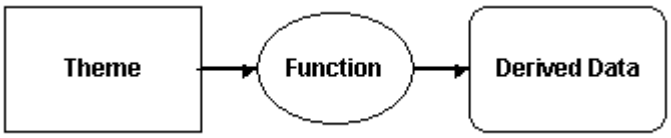


Figure 7.12

5. Choose the Theme and Set the Properties using "Property Sheets"

A. Right click the "Theme" node and click **Properties.** A property sheet (see figure 7.13) will show up. Set the properties as shown in the figure. Click "OK". Notice that it is just one sheet and not a wizard.

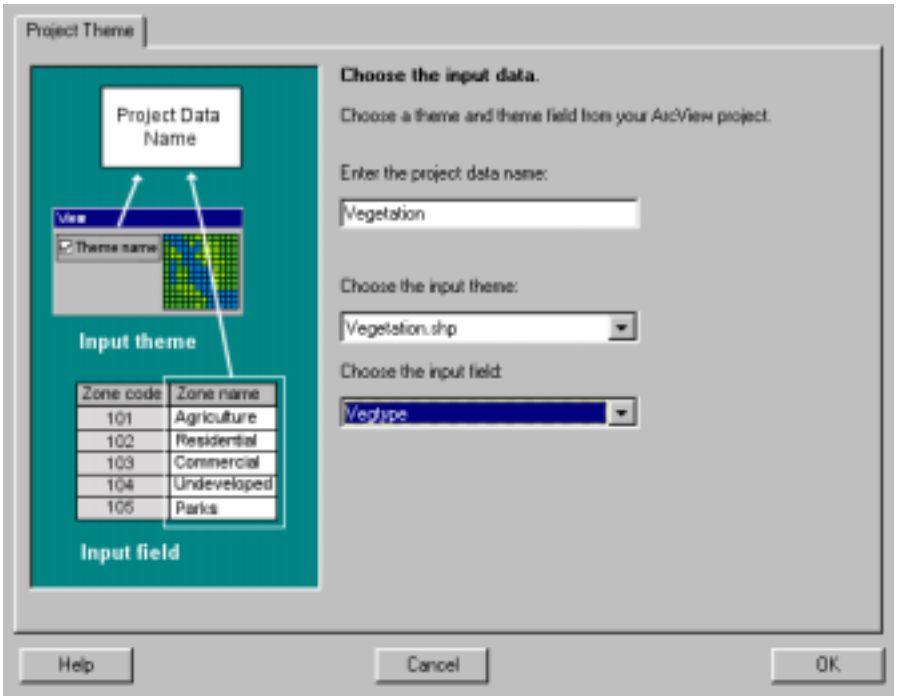


Figure 7.13

Figure 7.14

Once you click OK, the node will be blue, indicating the properties are set for this part of the process (Figure 7.14).

B. Right click "Function" node and choose, **Data Conversion – Vector to Grid.** Once you do this, the nodes will change name and color as shown in Figure 7.15.

Figure 7.15

C. Right click "Vector Conversion Map". Enter properties in the property sheet as shown in Figure 7.16 and click "OK". You can also enter properties for the legend, extent, cell size and documentation, in this property sheet. We will leave everything as default settings.

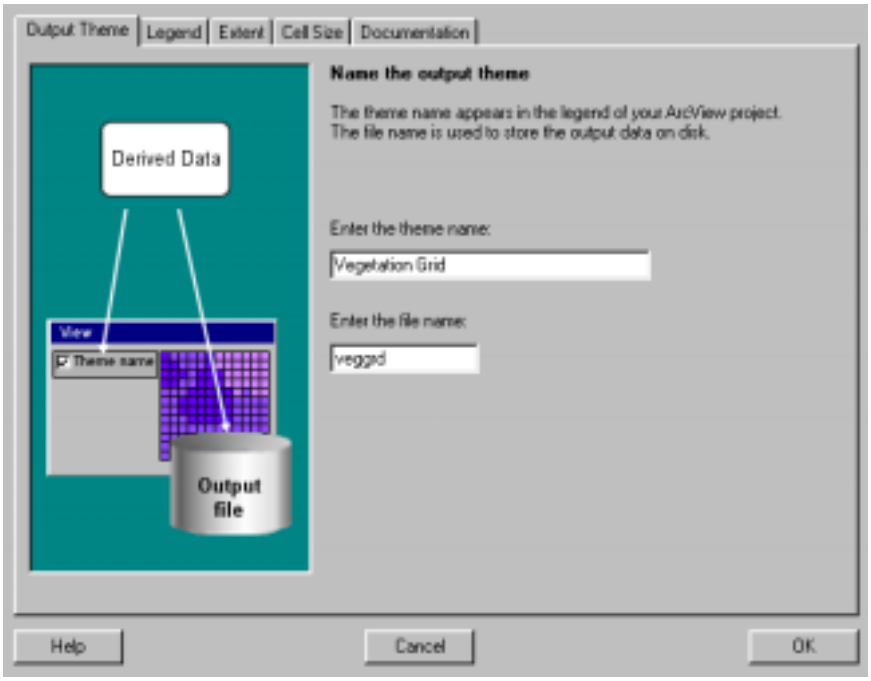


Figure 7.16

The name of the "Derived Data" is "Vegetation Grid".

6. Run the Model

When the "Save As" dialog box comes up, name the model "Exercise7_1" and click "OK". Now the model runs. Open the View and look at the new Grid Theme.

7. Change the Properties

Right click "Vegetation Grid", click **Properties**, then when the property sheet shows, click the **"Legend"** tab. Change the color ramp to "Pastels". Click "OK" and run the model again. These new settings will overwrite the previous ones. Look at the View.

ModelBuilder is programmed to change property settings in the "Function" and "Derived Data" nodes at anytime, then rerun the model to see the changing results. Practice changing some properties then rerunning the model on your own.

Keep in mind that any changes made to this process will be overwritten.

7.2 Developing a Suitability Model

EXERCISE 3 ModelBuilder for Suitability of Building Site

You will use similar information as in Exercise 2 in Chapter 6 – Surface Analysis for a Suitable Site on page 6-73. You will create a hillshade, slope and aspect grid from the elevation grid file.
Remember that the following are the criteria that our landowner is interested in for siting her new barn:

1. Elevation is greater than 300 feet and less than 600 feet.

2. Building must be on slope less than 10 degrees.

3. The building must be in a partially north facing location in order to be protected from southerly storms.

4. It must be 1000 ft. from a road.

1. Open Arc View and Make a new View

A. Go to View – Properties and set the map units and distance units to feet

B. Go to File- Set Working Directory and set to gistemp

C. Add the following Themes to the view: (These are located in AdvancedArcViewData\in the Grids and McLane folders).

McIngrid
McLaneRoads.shp
Mclanefp.shp

2. Bring up ModelBuilder and Add the Hillshade Process

(Go to "Model" menu item. Click "Start ModelBuilder")

A. Go to **Add Process** menu, **Terrain – Hillshade** (Figure 7.17)

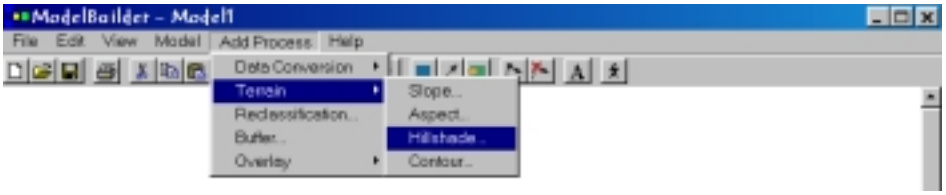


Figure 7.17

The Hillshade wizard comes up (Figure 7.18). Click "Next".

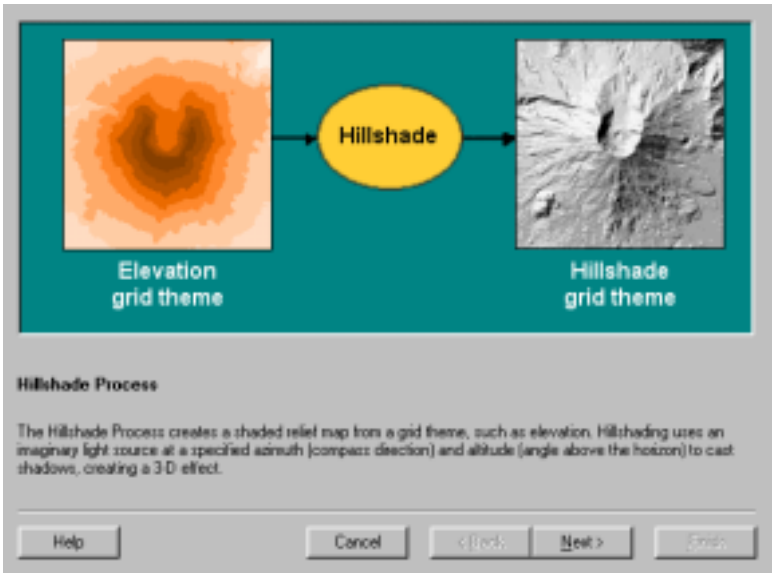


Figure 7.18

B. Make the input Theme "McIngrid", click "Next".

C. Vertical units should be "meters", click "Next".

D. Accept the defaults for Azimuth and Altitude, click "Next".

E. Click the Classify button in the Define Legend Table and choose the classification method shown in Figure 7.19. Click "OK".

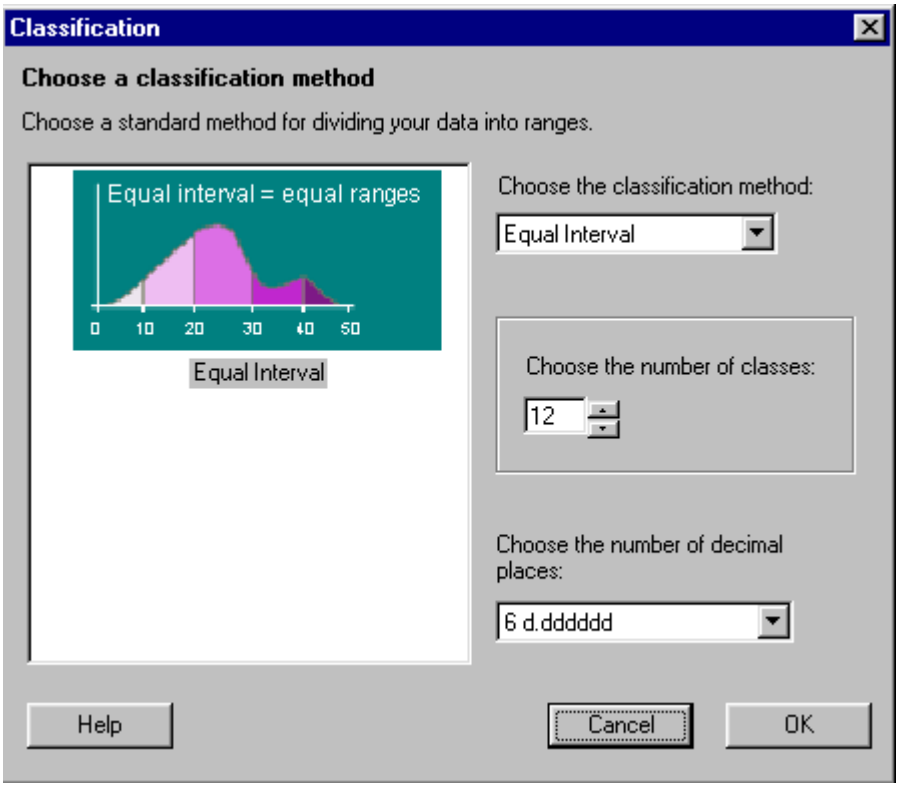


Figure 7.19

F. Make sure the color ramp is set to “Gray Monochromatic”, click “Next”.

G. Keep the output theme as the extent of the input theme, click “Next”.

H. The cell size should be “The Cell Size of the Input Theme”, click “Next”.

I. Type the following comments: “computed hillshade from McIngrid.” click “Next”.

J. Name the theme “McLane Hillshade”, and the file name “hillshdgrd”, click “Finish”. Now the process is complete (Figure 7.20).

Figure 7.20

K. Run the process. Save the model as “Exercise7_3”. Notice the results in the View. If the hillshade brightness needs adjusting, go to the Legend Editor, click the “Advanced” tab and set brightness theme to “McLane Hillshade”.

4. Add the Slope Process

A. Go to **Add Process – Terrain – Slope**. The wizard comes up (Figure 7.21).

B. The input Theme is “McIngrid”, click “Next”.

C. Choose “Percent” as the method for calculating slope, click “Next”.

D. Make sure “meters’ are chosen for the vertical units, click “Next”.

E. Create a “continuous” grid Theme. Accept the values as they are in the classification table, click “Next”.

F. Accept red as the color ramp, click “Next”.

G. Accept settings for the extent, click “Next”. The cell size should be “The Cell Size of the Input Theme”, click “Next”.

H. Skip documentation, click “Next”.

I. Name the theme “Slope Grid” and the file name “slopegrd”, click “Finish”.

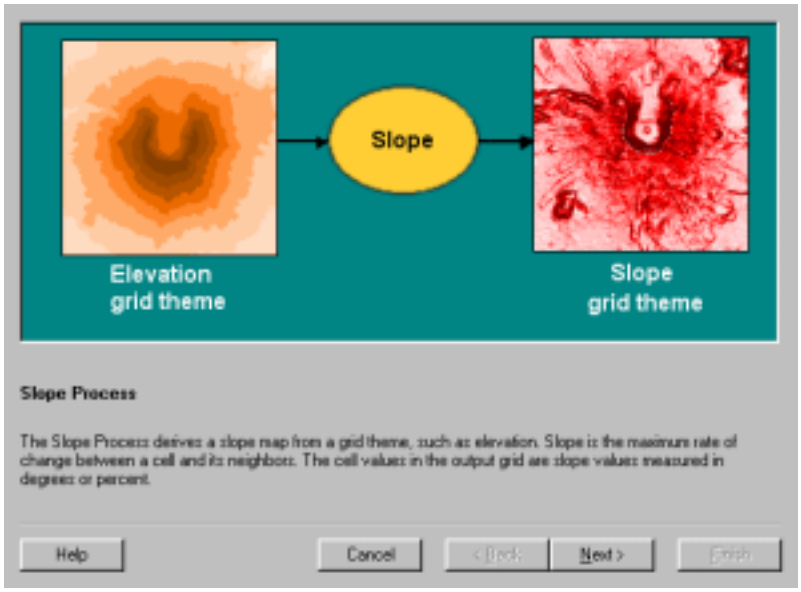


Figure 7.21

Notice what happened to the model (Figure 7.22). The same grid file was used for two different processes so the program linked them together in a flow chart. Also notice that one process is shadowed. That’s because it has been run.

C. Run the model again. Only the newly added process will run. Look at the new Grid in the View.

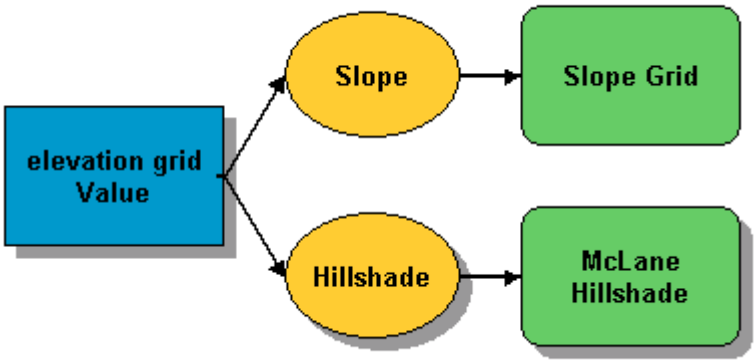


Figure 7.22

5. Add the Aspect Process

A. Go to **Add Process – Terrain – Aspect**. The wizard comes up (Figure 7.23).
B. The input theme is "McIngrid", click "Next". Create a "continuous" grid theme.

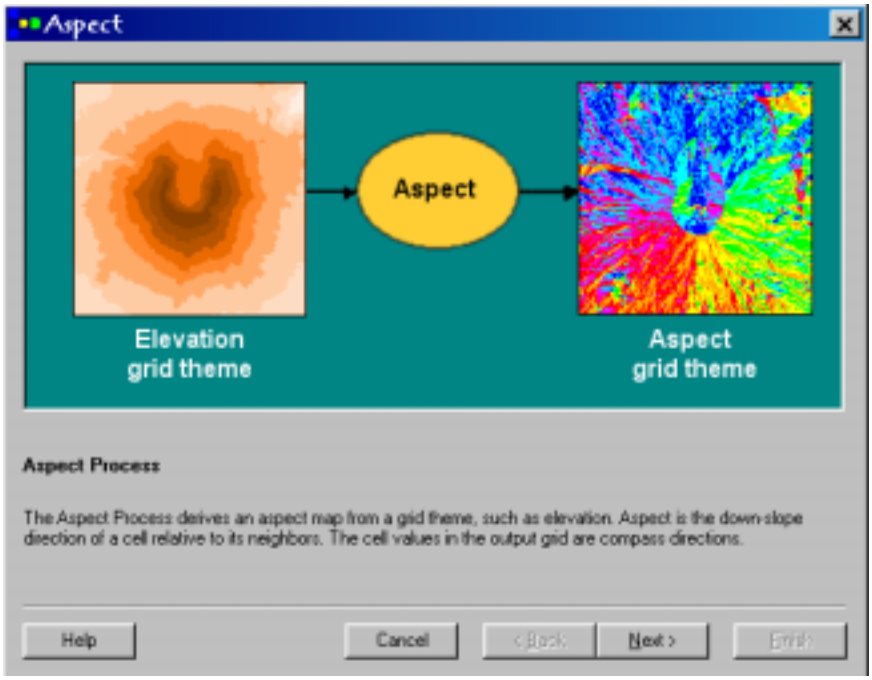


Figure 7.23

C. In the classification table choose the second compass rose down on the left which is the one that divides the directions into four sections, (Figure 7.24) click "Next".

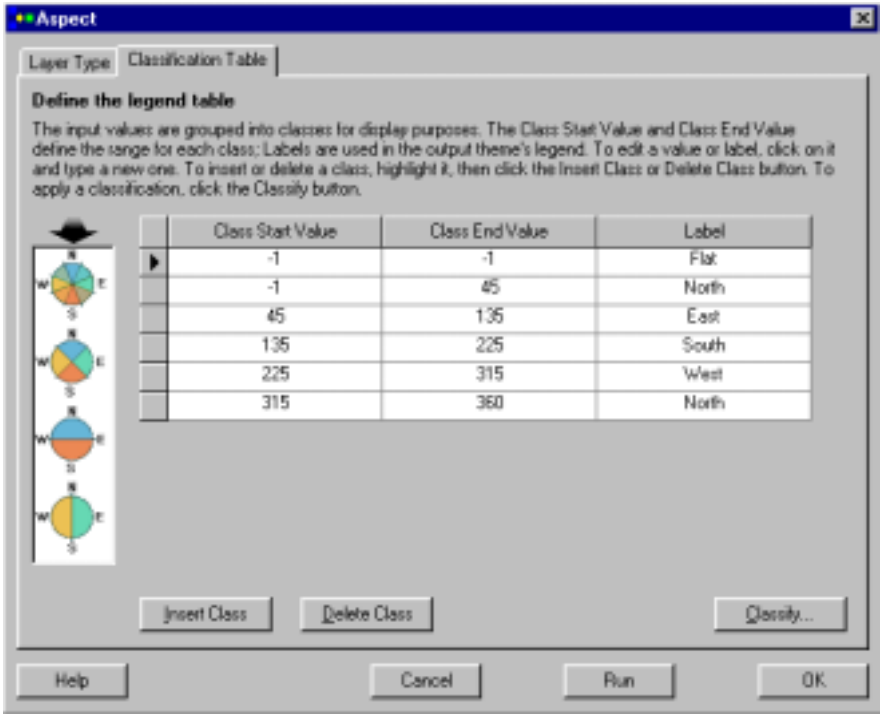


Figure 7.24

D. Accept the default color ramp, click “Next”. Accept settings for the extent, click “Next”.

E. The cell size should be “The Cell Size of the Input Theme”, click “Next”. Skip documentation, click “Next”.

F. Name the theme “Aspect Grid” and the file name “aspectgrd”, click “Finish”. Another process has been added to the model (Figure 7.25).

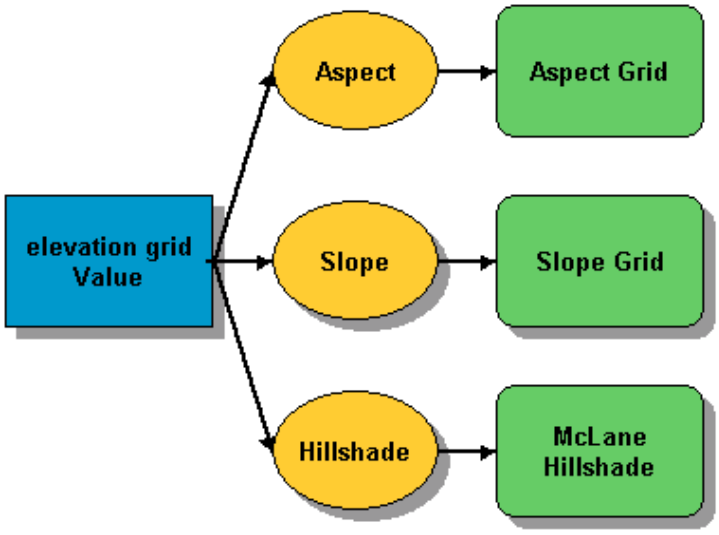


Figure 7.25

G. Run the model again. Now you have all three Grids, “McLane Hillshade”, “Slope Grid”, “Aspect Grid” to work with.

6. Find a Suitable Site for the Barn

In the View go to **Analysis** menu and run **Map Query**. Enter the same expression as in Exercise 6.1 (see Figure 7.26).

Before you enter the expression in the Map Query look at the values of your Aspect Grid. Determine which values represent north.

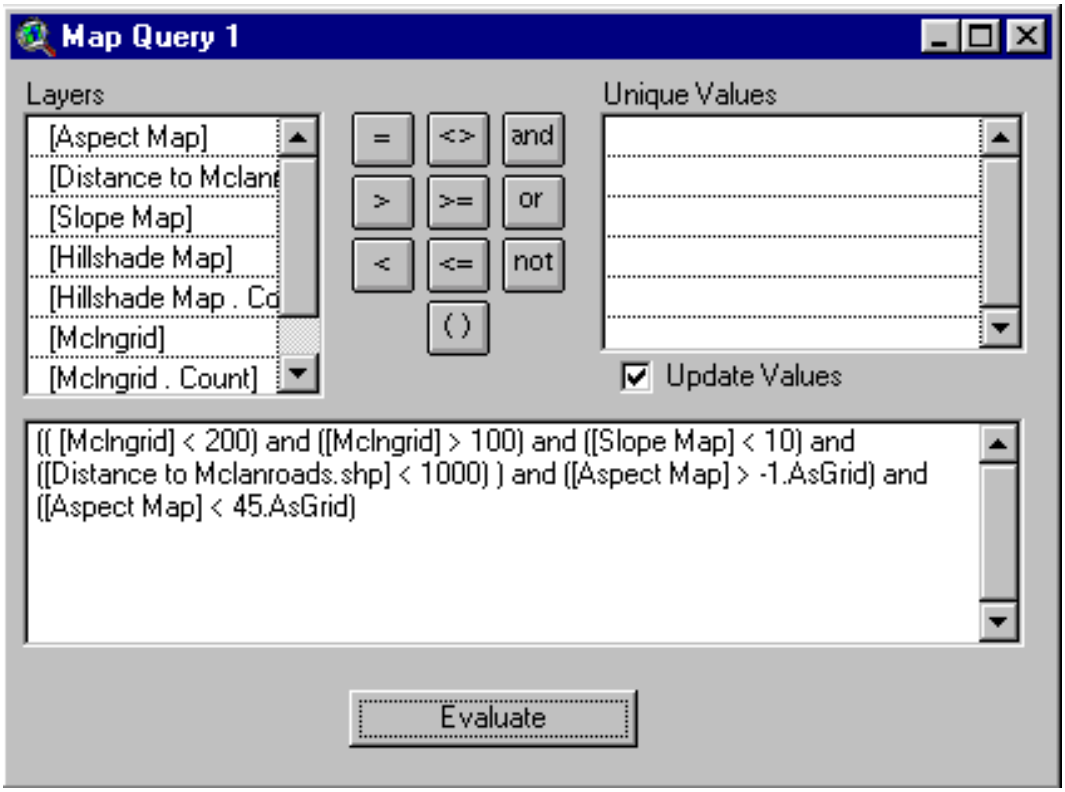


Figure 7.26

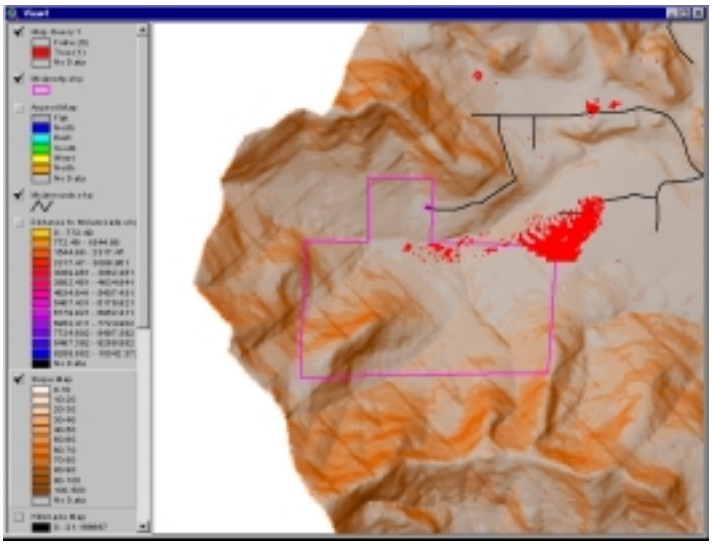


Figure 7.27

Figure 7.27 shows the results of the query for the exercise you just completed and Figure 7.28 shows the results of Exercise 1 in Chapter 6. What could be causing the difference? It could be that the aspect values in the query are different. This illustrates that minor differences in attributes that are used in your map query can cause differences in results. Remember that these two exercises were types of surface modeling. That is, each model approximates what is actually on the ground. It is up to you to determine which model best approximates reality based on your knowledge of the data.

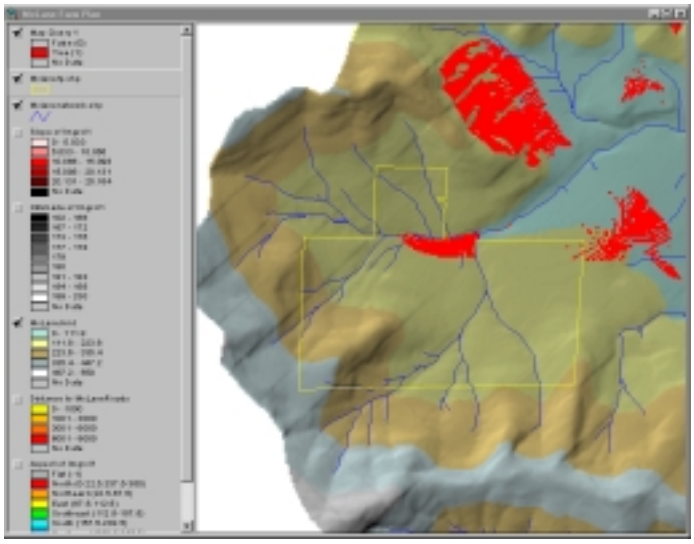


Figure 7.28

7. Save the model and close out of ArcView

8.0 Hydrologic Modeling With Spatial Analyst

What you will learn:

How to use the Hydrological Modeling Extensions that are included with the Spatial Analyst:

- How to delineate watersheds
- How to delineate stream networks
- How to find stream flow direction and stream path

GIS can be a very useful tool for in-stream Timber-Fish-Wildlife (TFW) monitoring for watersheds. Generally, the following characteristics of a watershed are surveyed and monitored using the TFW methodology:

- Stream Segments
- Reference Points
- Habitat Units
- Large Woody Debris (LWD)
- Salmonid Spawning Gravel Composition

Other characteristics that can be surveyed and monitored include:

- Stream Temperature
- Stream Sedimentation
- Riparian Conditions
- Watershed Conditions
- Flow and Climate Data
- Fish Populations
- Sensitive Amphibians
- Aquatic Insects

A global positioning system (GPS) is very useful for mapping these watershed characteristics. With one, exact locations of features can be mapped and attributes can be attached to each feature.

A Digital Elevation Model or DEM is the type of data that is used for mapping and analyzing topography. For a more detailed explanation of DEM data and where to get it see Chapter 6 – Raster Data & Spatial Analyst.

There are 2 hydrological analysis extensions that come with the ArcView Spatial Analyst. Hydrologic Modeling and Hydrologic Modeling v1.1.

These extensions can be found in ArcView help under Extensions – Spatial Analyst – Sample Scripts and Extensions – Sample Extensions. For this exercise we will be using the Hydrologic Modeling extension.

To use these extensions you first need to copy the extensions from C:\ESRI\AV_GIS30\ARCVIEW\Samples\ext to C:\ESRI\AV_GIS30\ARCVIEW\Ext32. After you do this you will be able to load the extensions in ArcView by going to File – Extensions and checking the box on the left of each extension.

Much of the Hydrologic Modeling Extension for ArcView was created by the Engineering Computer Graphics Laboratory at Brigham Young University. For more information on the extension and hydrologic modeling in general, visit their website at: http://www.crwr.utexas.edu/gis/gishyd98/byu/byu.htm

The Arc View Hydrologic Modeling Extension makes it possible to create watersheds and stream networks.

The Hydrologic Modeling Extension menu has choices to set properties, Fill depressions in an elevation grid theme, calculate Flow Direction, calculate Flow Accumulation, calculate Flow Length, and delineate Watersheds.

The two tools added by the extension require certain Properties to be set. The Watershed tool  works off an active elevation grid theme that has been filled. It will create a watershed from a point specified on the view. The Raindrop tool  works off of an active elevation grid theme that has been filled. It will trace the path of flow from a point specified on the view to an outlet.

Exercise 1 Using DEM Data to Create Hillshaded Elevation

Much of the DEM data available from the USGS uses meters for elevation value. The first thing to do with the DEM is to add a field in the attribute table that will convert the elevation values of meters to feet. This is done with the **Field Calculator**.

1. Make a new Project and call it "project7_1.apr".

Open the attribute table for the *Mcingrid* theme. *Go to Table – Start Editing*. Now add a field called ElevFt. Fill out the Field Definition dialog box as shown in figure 8.1

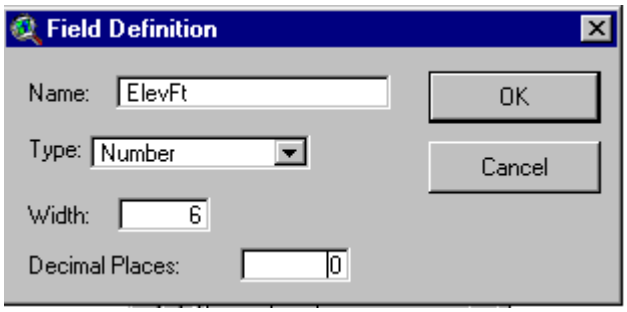


Figure 8.1

2. Select the ElevFt Field and go to Field – Calculate.

You will see the following dialog:

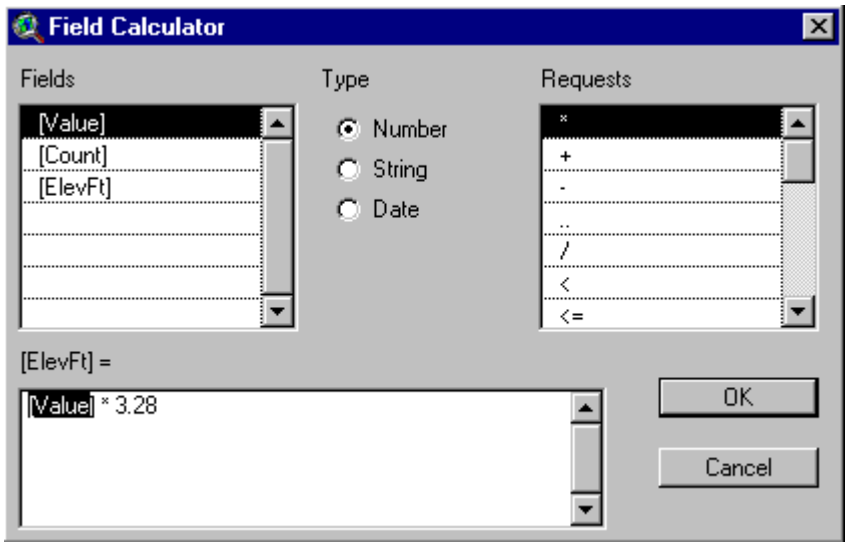


Figure 8.2

Create the expression as shown in Figure 8.2. The easiest way to do this is to double click [Value] then double click *, then type in 3.28. Remember that the expressions in the Query Builder can be done in same way. This helps to avoid the dreaded syntax error message.

Click OK. Your new **ElevFt** field should now be populated with values in feet.
Go to **Table – Stop Editing** and save edits.

3. Go to Legend Editor and change the Classification to "Natural Breaks"

Double Click the McIngrid theme to open up the Legend Editor. Change the Classification Field to **ElevFt**.

Click on the Classify button and look at all the available types of classification. Try different ones and watch what happens to your data. (Refer to Chapter 5, Layouts and Cartographic design for an explanation for each of the classification methods. Notice

which classification provides the best representation of the range of elevation data in the DEM).

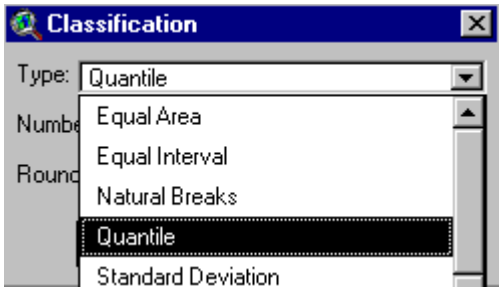


Figure 8.3

For this exercise, choose "Natural Breaks" with the number of classes set to 10. Change the color scheme to "Elevation #2".

Next we are going to create a hillshade from the grid. Go to **Surface – Compute Hillshade.**

After the hillshade has been created double click on "Mclngrid" to open the legend editor. Click on the advanced options button (figure 8.4).

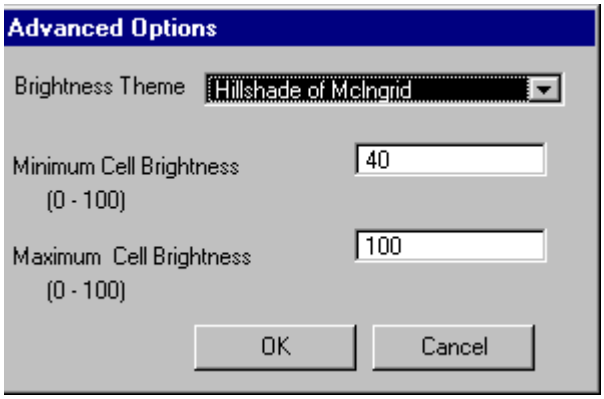


Figure 8.4

Chose "Hillshade of Mclngrid" for the Brightness Theme and change the minimum and maximum cell brightness values reflect those shown in figure 8.4.

Your View should now look like Figure 8.5.

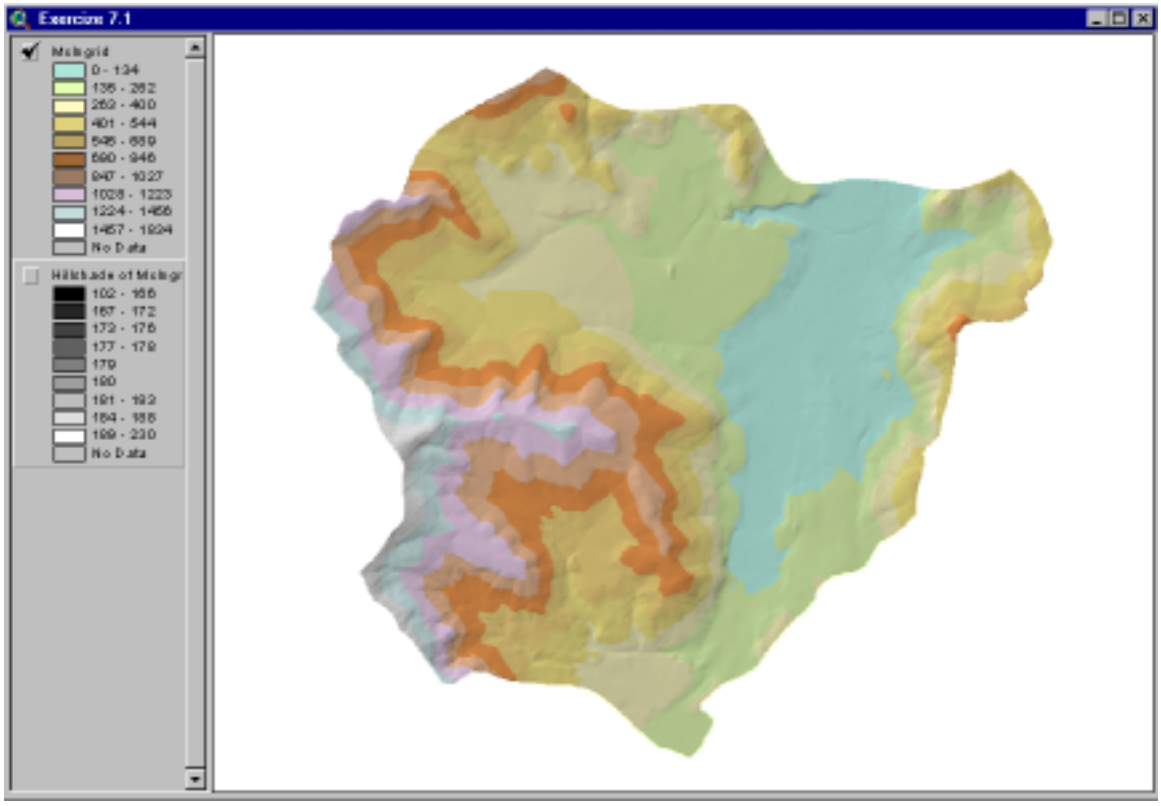


Figure 8.5

Note: If you are going to print a map like this with ArcPress remember that you cannot have any data values that are transparent. To prevent this problem open the Legend Editor and make the No Data value opaque by choosing a color such as white.

8.1 How to Create Stream Networks

The next step in our habitat study GIS project for McLane Creek is to delineate sub-watersheds and create a stream network shapefile.

Exercise 2 Using DEM data to Delineate Watersheds and Create a Stream Network

1. Go to File – Extensions and load Hydrologic Modeling

You will see a new pull down menu item called Hydro with several options underneath (Figure 8.6.)

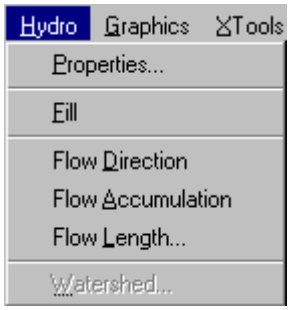
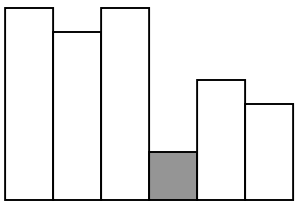


Figure 8.6

2. Fill "Sinks"

The first step in our stream network delineation is to use the "Fill" option to identify and fill all of the sinks in the Mclngrid Theme. Make sure Mclngrid is active and choose the Fill option.

Note: Sinks are areas surrounded by higher elevation values (see graphic). Typically 1% of cells in a 30m resolution DEM are sinks and the rest are naturally occurring depressions. The 1% of sinks should be removed before doing suface hydrology analysis. If they are not filled, then water flowing into a sink is trapped and the drainage path is stopped at that cell.



3. Determine Flow Direction

Make the filled Mclngrid Theme active and choose “Flow Direction”.

4. Determine Flow Accumulation

Make the flow direction Theme active and choose “Flow Accumulation”.

Your View should look something like Figure 8.7. This may not look like much of a stream network. This is because we must classify the data so that the network will be visible.

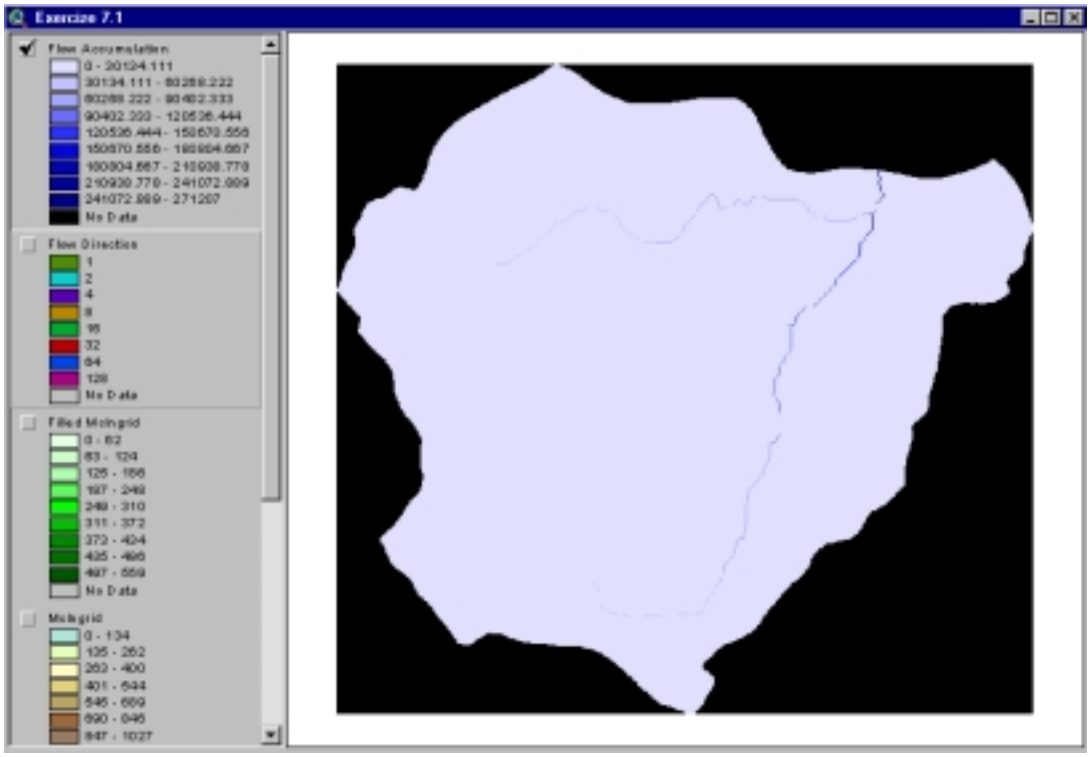


Figure 8.7

Make the Flow Accumulation Theme active and double click to bring up the Legend Editor. Click the Classify button and choose “Standard Deviation” and “Break Classes” as “¼ Std. Dev.” as in Figure 8.8. Click Apply.

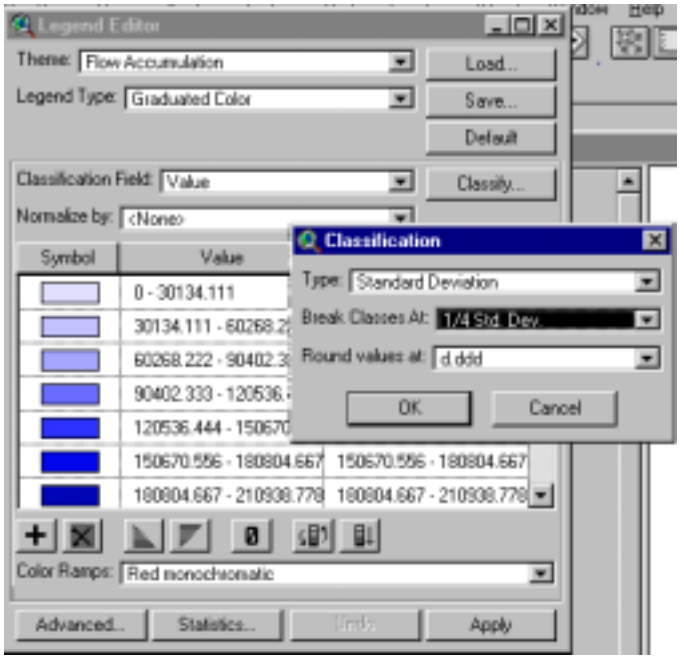


Figure 8.8

Your View should now look like Figure 8.9.

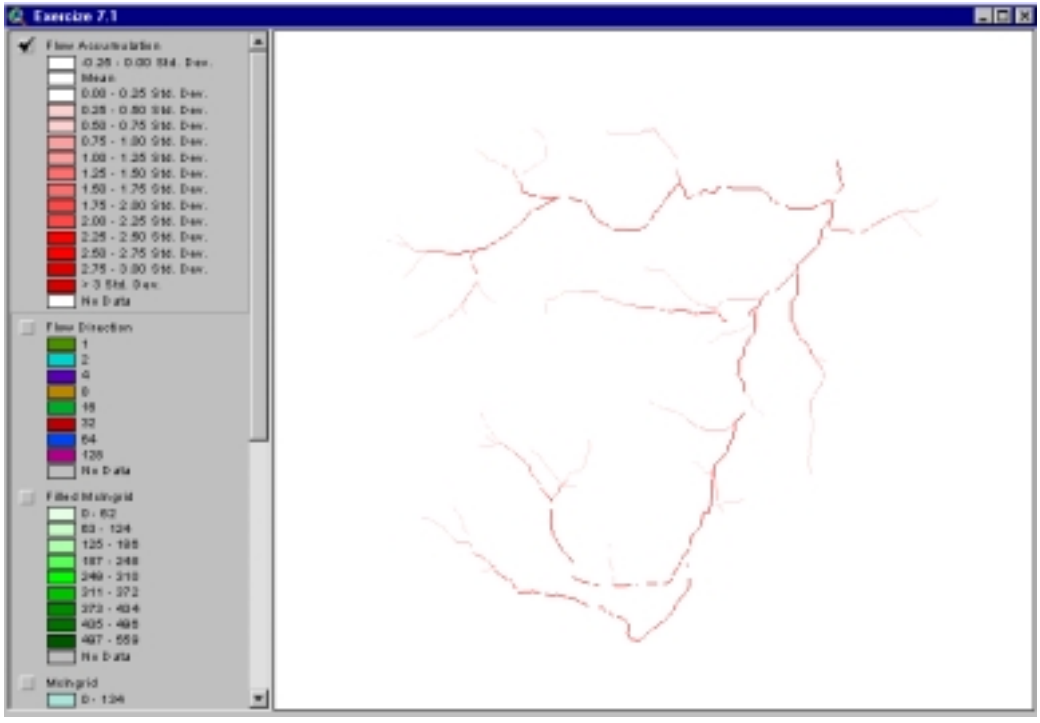


Figure 8.9

5. Change the Colors of the Flow Accumulation Theme Values as shown in Figure 810.

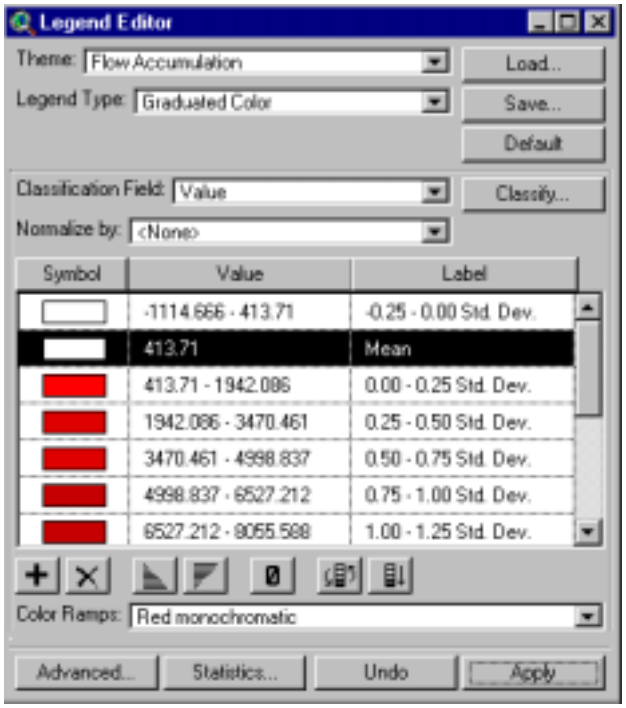


Figure 8.10

Choose the Red Monochromatic color scheme and change the colors of the mean value and the value below it to white. Click Apply. This will make the network more visible. Your View will now look something like Figure 8.11.

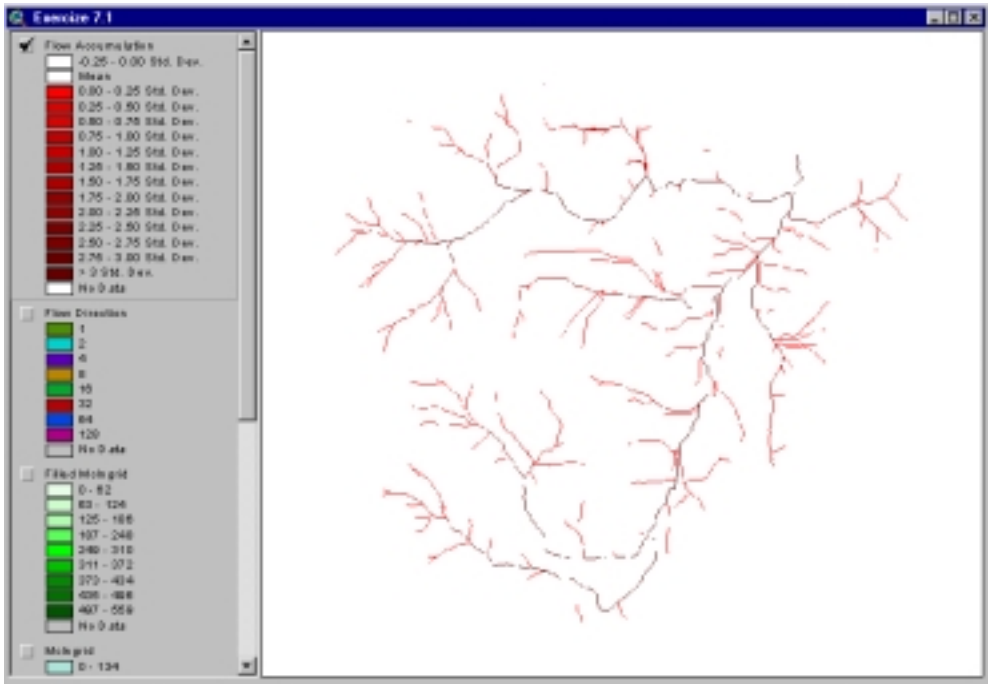


Figure 8.11

In order to convert the stream network to a vector based shapefile we must separate the stream network grid cells from the background grid cells. To do this we must first Reclassify the grid. That is, we need to change the Flow Accumulation grid from a *floating point value* to an *integer value*. What does this mean?

The short answer is that integer value grids generally have an attribute table associated with them. Whereas floating point value grids generally do not have an associated attribute table. Because of this it is not possible to query groups of values because a floating point grid can have separate values for each cell in the grid. We need to select all of the cells from the Flow Accumulation that match the values for the stream network. This would not be possible with the Flow Accumulation grid in floating point format.

6. Reclassify the Grid to "Integer Value"

Go to **Analysis – Reclassify**. You will see the following dialog (Figure 8.12).

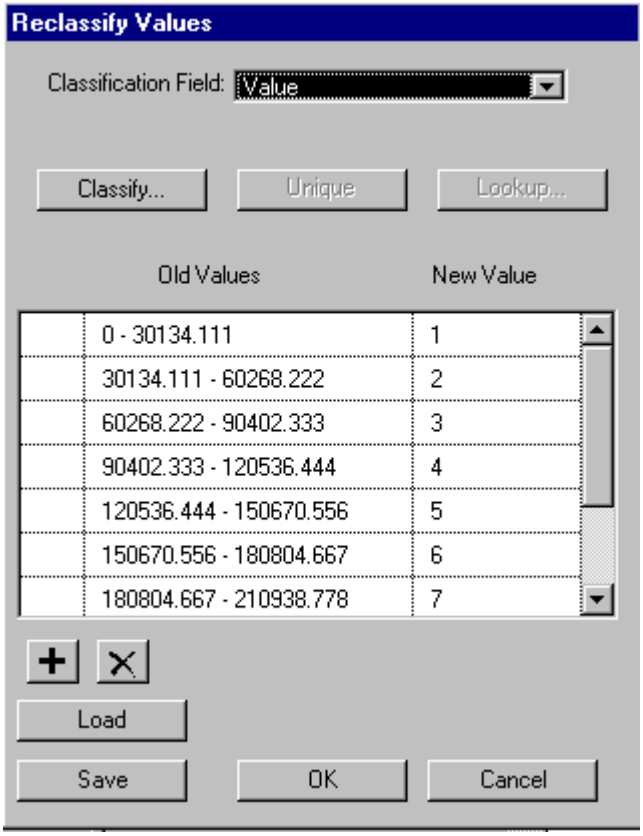


Figure 8.12

Click the Classify button and choose the settings as shown in Figure 8.13.

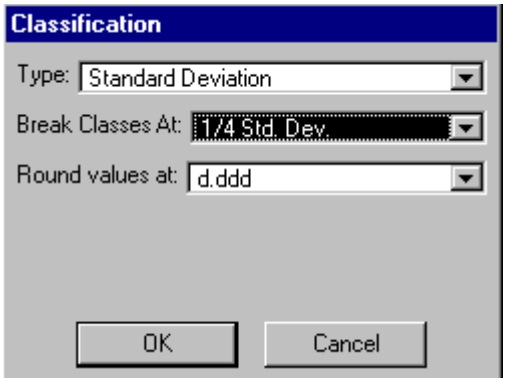


Figure 8.13

You should now have a new grid Theme in your view called “Reclass of Flow Accumulation”. This is the grid with the integer value.

The next step is to perform a query on this theme. Go to **Analysis – Map Query**.

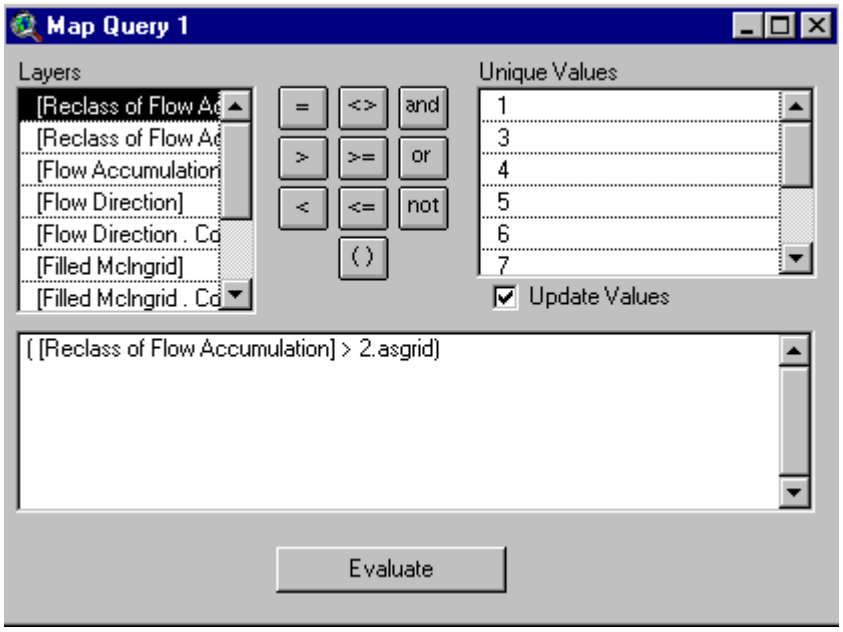


Figure 8.14

Type in the request exactly as shown in Figure 8.14. Remember that you can double click on layer name and the operators (=,+,(), etc.). Click the Evaluate button.

When you turn on the “Map Query 1” Theme your View should look something like Figure 8.15.

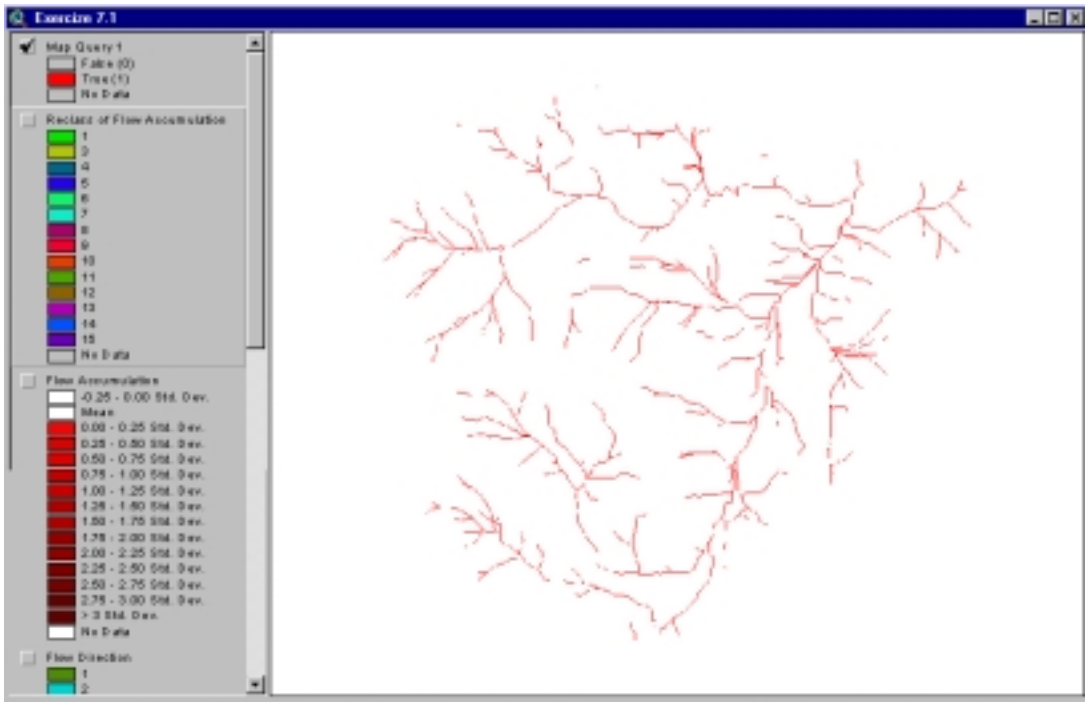


Figure 8.15

7. Convert the "Map Query 1" Theme into a vector line Theme.

To do this we will use a special script written by Kenneth R. McVay which can be obtained from the ESRI Arc Scripts web-page. The script is called **R2v.zip**. The zipped script package contains scripts for conversion of points, polylines and polygons. There are other scripts out there to perform this conversion but this one seems to work the best by not creating "chunky" looking vector lines.

A. Download the script, **View.R2Vline** for this exercise. (See Section 3.2 "Adding Scripts and Extensions", for instructions on how to download, unzip, load, compile and associate the script to a button on your Graphical User Interface (GUI)).

B. Activate the script once it's properly installed. .The first dialog asks you for a file name and location. Choose the defaults.

C. In the second dialog box choose the **No** button (Figure.8.16).

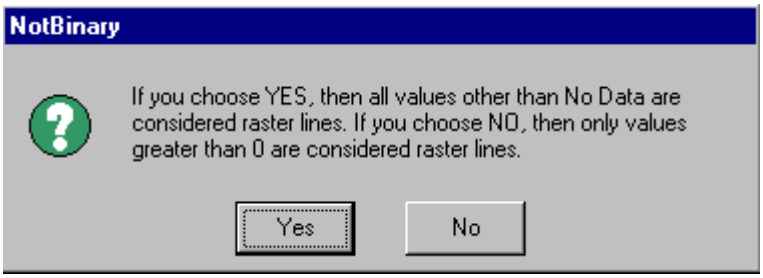


Figure 8.16

D. In the third dialog box choose **Yes** to perform weeding (Figure 8.16).

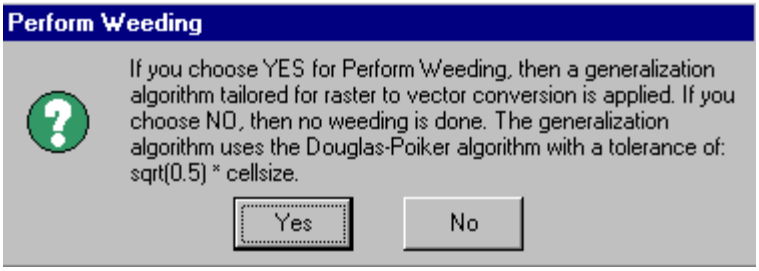


Figure 8.17

E. Zoom into an area in your view and compare the new vector stream network Theme with the raster Map Query 1 Theme (Figure 8.18). Notice that the vector Theme is not very "chunky" looking. But also notice that there are areas where the vector line has been transformed into squares. The reason for this is that stream network delineation is difficult in areas that are relatively flat. Additionally, a 30 meter DEM grid was used for this exercise. Each of the squares represents the 30 meter cell size. The reason for this is that in flat areas, the water "doesn't know" where to go. These areas can be verified in the field and the shapefile can be edited to correct the uncertain areas.

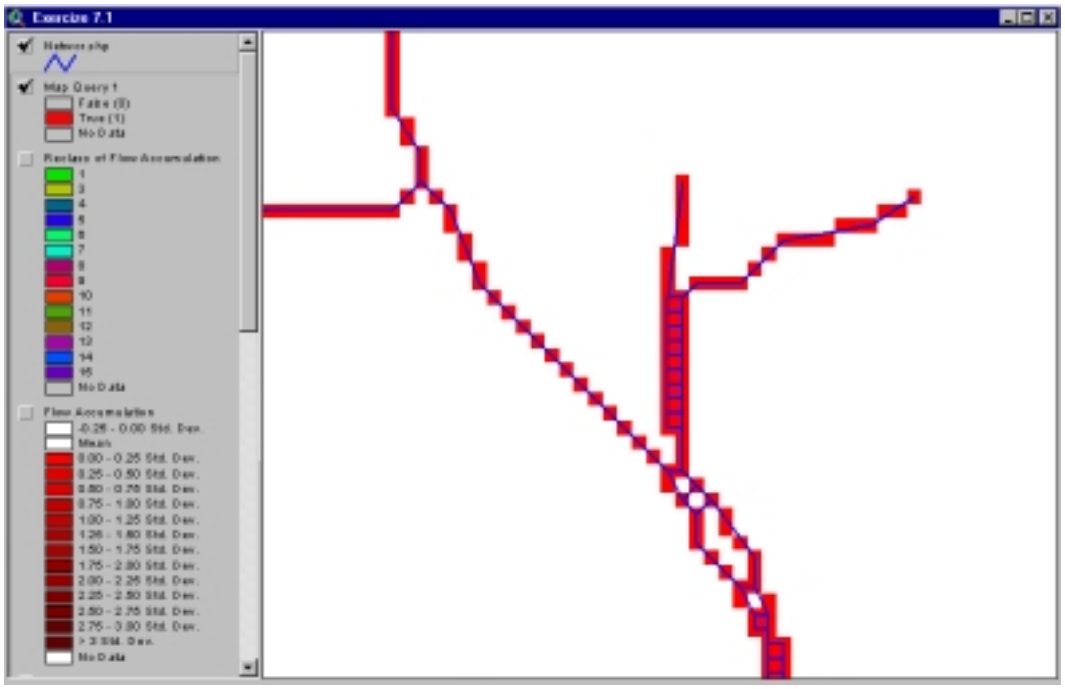


Figure 8.18

Remember that the accuracy of the watershed delineation is compromised to a large extent in areas that are relatively flat. It is up to you to ensure that your GIS data is accurate so go out in the field with the GPS to verify the location of tributary intersections and other features.

8.2 Watershed Delineation

Exercise 4 Using the Hydrologic Modeling Extension to Delineate Watersheds

1. Set Hydro Properties

Setting these properties makes it possible to use the Delineate Watersheds and Trace Flow Path buttons that come with the Hydro extension.

A. Go to **Hydro – Properties**. The following dialog appears (Figure 8.19)

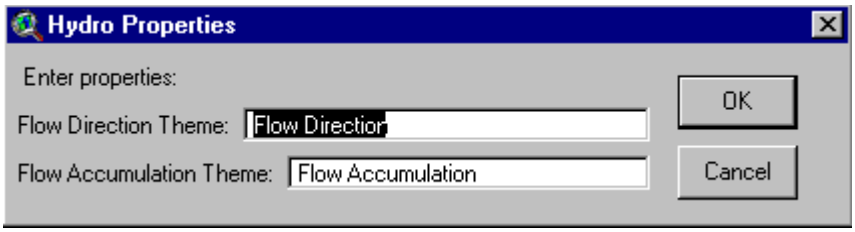


Figure 8.19

B. Fill in the Flow Direction and Flow Accumulation properties as shown in Figure 8.20.

C. Make the Flow Accumulation grid the active Theme. Now we will use the watershed delineation function. Go to **Hydro – Watershed**. The following dialog appears (Figure 8.20).

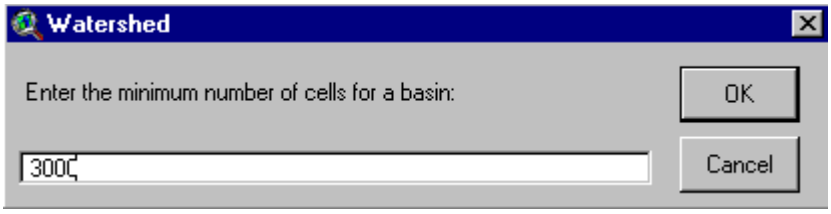


Figure 8.20

Make the minimum number of cells 3000 as shown in Figure 8.20.

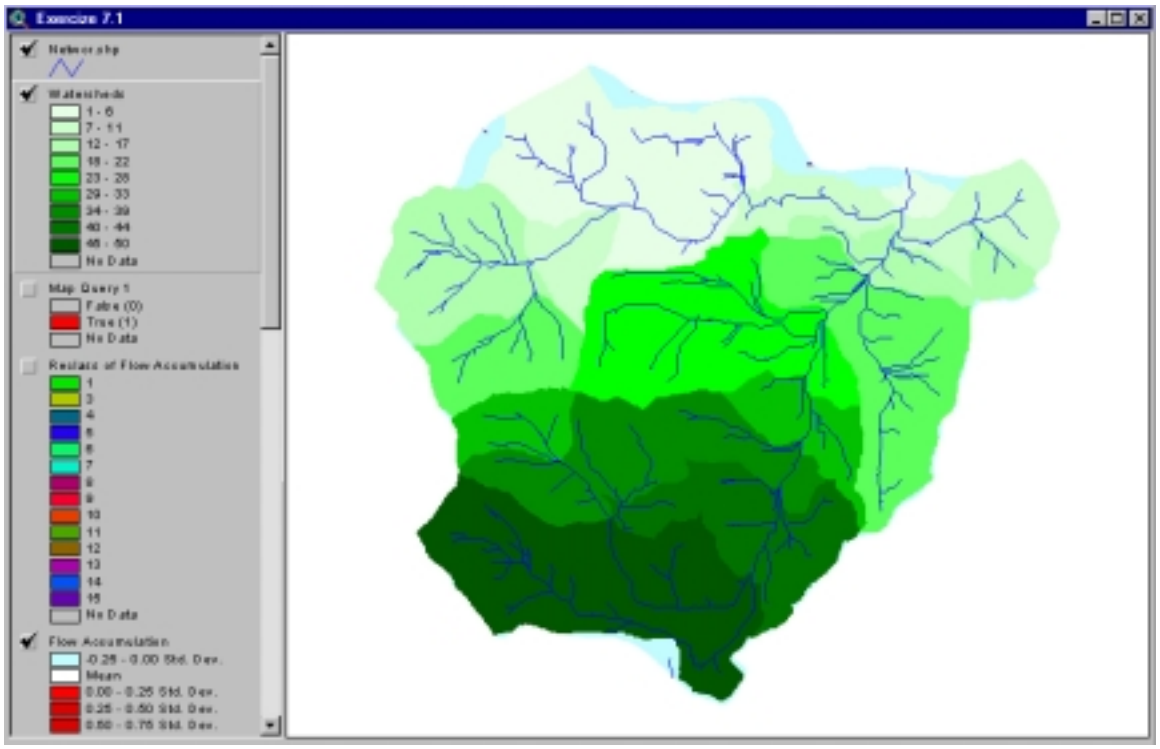


Figure 8.21

Your view should look something like Figure 8.21. Remember to move your stream network vector Theme that you created in the previous exercise to the top of the Themes in the left part of your View. Now you can see the relationship between the stream network and the associated watersheds. You can always change the number of cells used for the analysis to create larger or smaller watersheds. Notice that there are areas on the edges of the grid that are not included in a watershed. This is probably because of inaccuracies in the watershed shapefile that was used to clip the source grid. Always be aware of the accuracy of your data.

8.3 Stream Flow Direction and Flow Path Determination

Exercise 5 Using the Hydrologic Modeling Extension to Determine Stream Flow Direction and Flow Path

The watershed and flow path buttons in the Hydrologic Modeling Extension can be useful for analysis of small areas in your study area.

Watershed and Flow Path Buttons

> **Note:** The watershed button is not useful because you can't adjust the number of cells in the watershed. However, you can change number of cells in the pull down menu.

To use the watershed button click the it and then click on the location in your View where you would like to know the extent of the watershed.

The flow path button traces the path of a theoretical drop of water from a point in your View that you choose.

To use these buttons make sure the Hydro Properties are set for the flow direction and flow accumulation Themes. Then click on the locations you are interested in. The number of cells used for the watershed button is fixed.

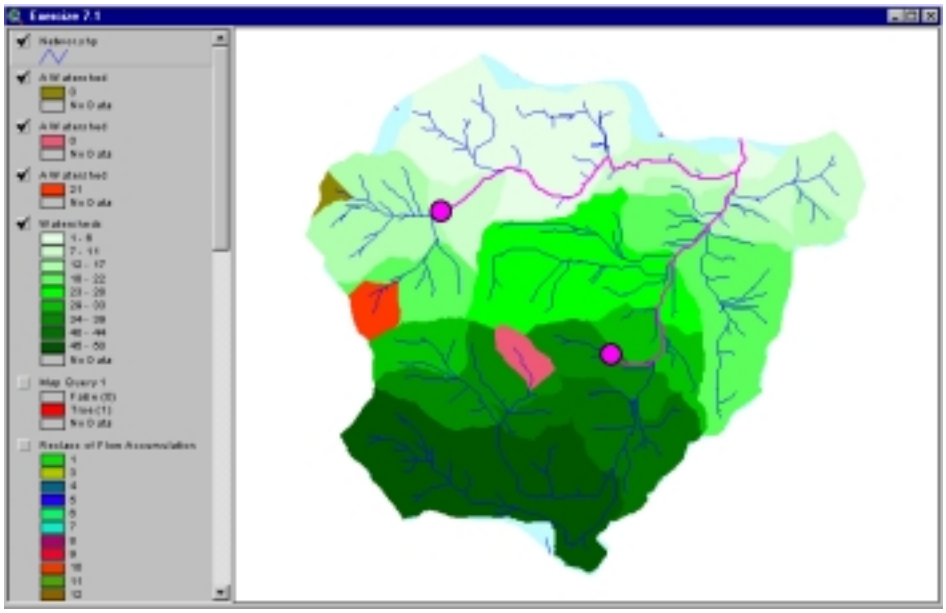


Figure 8.22

In Figure 8.22 you can see the results: 3 watershed queries and 2 flow path points.

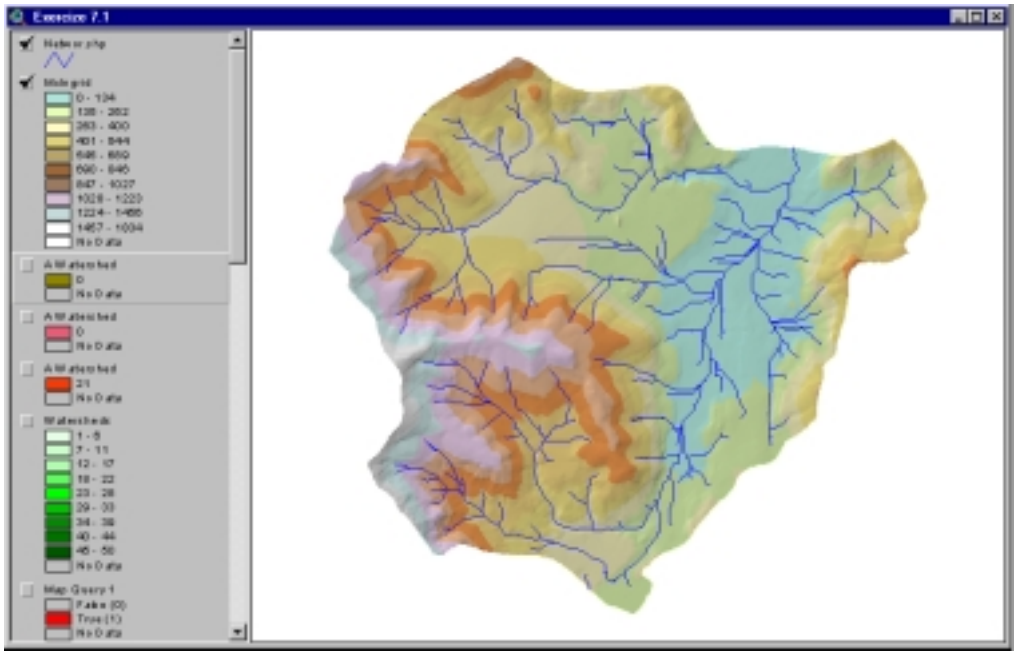


Figure 8.23

Figures 8.22 and 8.23 show the results of your efforts. There is much more you can do with hydrologic modeling with the Spatial Analyst. These exercises only scratch the surface of what is possible.

GPS For Conservation Districts & USDA Partners

What is GPS?

GPS stands for the **Global Positioning System** which is operated by the Department Of Defense. Currently the DOD has 27 Navstar satellites orbiting the earth every 12 hours providing continuous positional information. These satellites transmit coded radio signals that allow GPS users to determine location very precisely. Positional accuracy depends on the sophistication of the receiving unit, the processing and the time available for reception.

GPS consists of three components: space, control and user.

- The space component consists of the satellites themselves.
- The control component monitors the satellites and transmits update information to them.
- The user component is anyone using a GPS receiver.

How GPS works

GPS operates on the principal of triangulation. By knowing the distance from where you are, to three points (in different directions) you can determine your location. With GPS we are dealing with the same principal but using time instead of distance. This works because time multiplied by velocity equals distance. The Velocity of satellite signals is that of the radio wave – 186,000 miles per second. (the speed of light) By knowing the location of four satellites and the time that the signal left each satellite a GPS receiver can determine its location. The fourth satellite is needed to calibrate the clock in the receiver to the clock in the satellite.

Here's how GPS works in five logical steps:

1. The basis of GPS is "triangulation" from satellites.
2. To "triangulate," a GPS receiver measures distance using the travel time of radio signals.
3. To measure travel time, GPS needs very accurate timing which it achieves with some special tricks.
4. Along with distance, you need to know exactly where the satellites are in space. High orbits and careful monitoring are the secret.
5. Finally you must correct for any delays the signal experiences as it travels through the atmosphere.

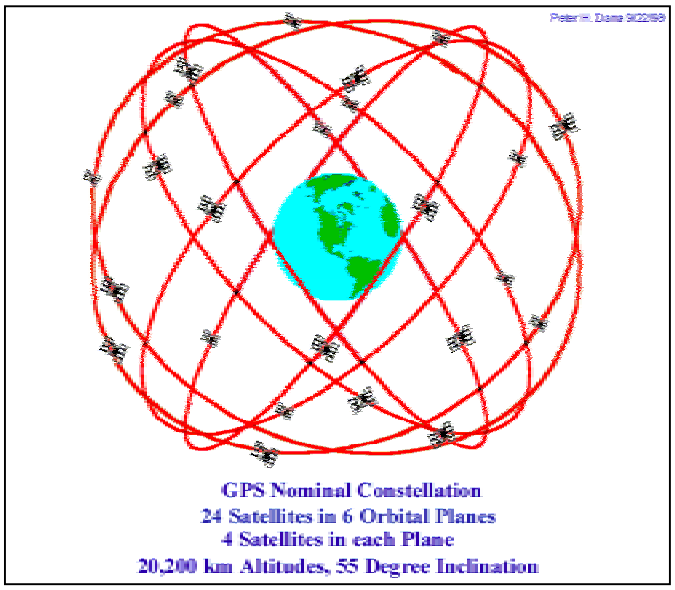


Figure 1. GPS Satellites

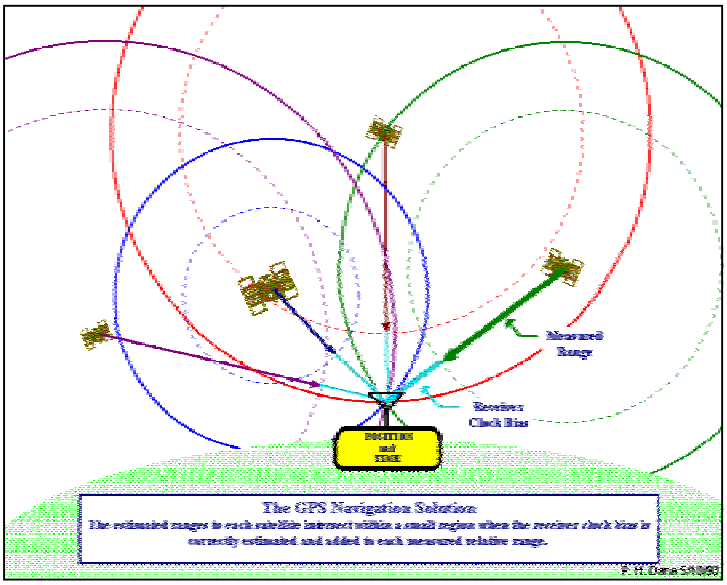


Figure 2 The GPS Navigation Solution

Uses of GPS

These are some of the applications that GPS is currently being used for:

- GIS data capture
- Vehicle tracking
- Marine/vehicle navigation
- Surveying
- Emergency services
- Aviation

- Agriculture
- Recreation

How are GIS and GPS used together?

- GPS can be used to ground truth the accuracy of some CAD or GIS data sets that have few identifiable land marks.

- Most GIS data sets are digitized off of USGS quads where the accuracy is limited to 40 feet or so. Most GPS receivers that are capable of differential correction are accurate to within 10 feet.

- GPS can be used to create new data sets with attributes that can be linked with existing GIS data to produce maps or reports.

- Most new GPS units can export data into Arc\Info, D-base, Ascii text, Arc View Shapefiles ,and many other popular software programs.

Types of Data That Can Be Collected With GPS

Depending on the receiver, the following types of data can be collected with GPS:

- Points
- Lines
- Polygons/Areas

GPS receivers record data in one of three ways: points, lines and areas or polygons. All GPS receivers collect points. Some receivers can collect many points and average them a specified time interval. This result of this averaging is more accurate data. Some receivers can also collect line and area data. Line data is recorded as a series of points linked by a line which joins the points in the order they are recorded. Line data would be used to record a road, fence or stream bank. Area data is recorded in the same way as point data, but the last point collected is automatically joined to the first to form an area. Area could be used to record a lakeshore, stream buffer area or pasture.

GPS Error

There are many sources of GPS error. However, it is possible to correct for most of these using differential correction which will be discussed shortly.

These are some GPS error types:

- **Noise Errors:** Noise errors are caused by noise in the radio signal that the satellite receives and noise within the receiver itself.

- **Bias Errors:** Bias errors are the result of satellite clock errors uncorrected by the control segment.

- **Orbital or Ephemeris Errors**: The ephemeris contains predictions of satellite position at a given time. In other words, each satellite "knows" where the others are but there can be errors in this data.

- **Atmospheric Delay: Ionospheric and Trophospheric delays** The satellite signal slows as it passes through the atmosphere. The system uses a built in model that calculates the average but not the exact amount of delay.

  Note: Atmospheric delay is greatest during the heat of the day when ionospheric activity is at its peak.

- **Multipath errors**: Multipath errors occur when the signal from one or more satellites is reflected from a surface near the receiver. The receiver can mistake the reflected signal for the direct signal from the satellite. The surface might be a building a mountain or a tree.

- **Geometric Dilution of Precision (GDOP**): These errors result when the satellites monitored by the GPS receiver are too close together. GDOP has several components:

  - PDOP: Position Dilution of Precision (3-D)
  - HDOP: Horizontal Dilution of Precision (Latitude, Longitude)
  - VDOP: Vertical Dilution of Precision (Height)
  - TDOP: Time dilution of Precision (Time)

- **Blunder Errors**: Blunder errors include several types of errors including:

  - Control segment mistakes
  - User mistakes such as using an incorrect geodetic datum or projection.
  - Receiver errors from hardware or software failure

Differential Correction

Differential correction is a way to eliminate almost all error. It works by using a fixed reference station. The exact location of the reference station is at a known position and can determine errors in satellite signals. It does this by comparing the measured range to each satellite to the calculation of that satellite's known position. The result is a differential correction. The GPS receiver uses this signal to correct its data.

There are two types if differential correction:

- Real-Time differential correction: Corrections can be transmitted by radio link. A reference station (A GPS receiver placed in a fixed location) can transmit corrections which the GPS receiver can receive.

- Post Processing differential correction: The data collected with a GPS receiver is transferred to a computer. Software is used to import differential correction information and to correct collected data.

Pre Project Planning

Satellite availability is intended to be adequate at every point on the earth. This is probably true if you have access to state of the art survey grade GPS equipment. However, for most GPS users it is a good idea to take the time to find out when you will have good satellite configuration at the location where you want to record data.

You can down load Quick Plan from Trimble's website. Quick Plan is a free software program that you can use to plan your project. It shows you the best days and times for satellite availability. You can download the software at:

http://www.trimble.com/support/files/qp.htm

Information about satellite positions is also available from:

http://sirius.chinalake.navy.mil/satpred/

It is necessary to plan data collection carefully. For a given point, what parameters do you want to record? Some GPS receivers allow you to load a data dictionary, the digital equivalent of a form. The receiver will then prompt you to enter each desired parameter when feature data is collected

Some receivers allow you to set masks for **elevation**, **PDOP** and **signal-to-noise ratio (SNR).** Setting the configuration properly will alleviate much error.

The elevation mask is the elevation above which a receiver can use a satellite to calculate a GPS position. For land based applications, where there are obstacles such as buildings or lush foliage an elevation mask of 15 to 20 degrees gives smoother performance. Lowering the mask improves the number of satellites tracked, but introduces increased troposphere noise. In addition the potential effects of multipath increase.

Position Dilution of Precision Mask (PDOP) indicates when the satellite geometry can provide the most accurate results. It takes into account each satellite's location relative to other satellites. A PDOP of 3-7 generally gives good positions (4 is excellent).

The signal-to-noise ratio (SNR) is a measure of the information content of the signal relative to the signal noise. As the proportion between the signal and noise decreases, data is distorted by the noise. Satellite elevation and atmosphere affect SNR. The typical signal strength of a satellite at 30 degree elevation is 12-20. A signal strength of less than 6 from any of the satellites being used can degrade the positional data.

What Type of GPS Unit is Best?

That all depends on what you are going to do with it. Before you can answer this question you need to ask the following questions:

- What spatial attributes are you trying to capture with our GPS equipment?
- What end product do you hope to generate from this data?
- What office software do you have available to process and store this data?
- What accuracy level do you need with our data?
- Do you need to post process or employ real-time corrections or both?

Frequently Asked Questions About GPS Receivers[1]

I heard that last year the US Government turned off Selective Availability which was used to purposely create inaccuracies in signals. Doesn't that mean that my inexpensive GPS unit will be much more accurate?

> The US Government's removal of Selective Availability improved GPS receivers UNCORRECTED accuracy to about 10 -15 meters from 50 - 100 meters. A big improvement, but for GIS and precise mapping/surveying applications, it had arguably no impact. We use the same tricks/process now as we did before to improve on this accuracy. We use differential correction. Differential correction removed all the SA error (this is why you are not getting any better accuracy after correction now - we were taking all of the SA out before anyway) and many other errors. Now (starting after May 1, 2000) you don't need to correct for SA (unless they bring SA back someday which the DOD retains the right to do so) but you still need to correct for atmospheric error, satellite (ephemeris) errors, etc. Its all of these other errors that are still giving the 10 -15 meters and its these error we still need to differentially correct to beat 10 meters.

[1] The responses to this FAQ are paraphrased from a response to a GPS question on the Conservation GIS Listserver from Richard Ash with Global Mapping Technology in Corvallis Oregon.

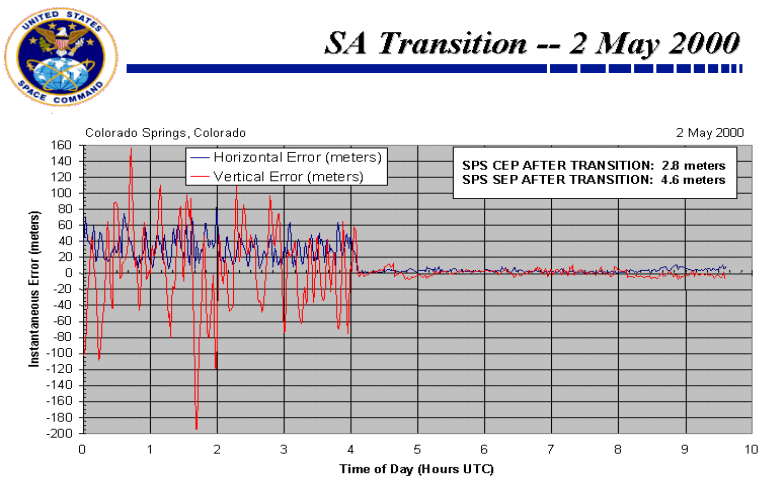


Figure 3 Selective Availability Transition

I know that there are two ways to differentially correct. Is one way better or more accurate than the other?

The two methods of differential correction are:

1. **post-processing** Correct later in the office - you need post-processing software to do this (and access to the internet to get Base Station data for the same time range you were collecting in the field)

2. **real-time** Correct at the same time you are collecting in the field. You need a beacon receiver attached to your GPS to do this.

Not all GPS machines can do "1". NOT all GPS machines can do "2". Decent Mapping Grade GPS can do both "1" and "2". Most inexpensive, recreational GPS CANNOT do either "1" or "2" - they are stuck at the 10 meter + range (typical accuracy).

Myth: Real Time correction beacons improve accuracy better than one can get with post-processing. This is False. The accuracy of post-processing and real-time correction is very similar and the results either way will be determined by the quality and capability of your GPS receiver. Post-processing has some advantage in terms of stability and it will also save you some money on the extra real-time equipment but you will need to spend some extra time for each job downloading the base station data and running the corrections (but this process has been largely automated/streamlined from days of yore).

The only time buying a beacon receiver would be absolutely required is if you want to re-locate a previously mapped or otherwise known position – for example you want to navigate back to the same soil sample site you mapped out a month

ago and you wanted to return within +/- 5meters. Otherwise, if you are just mapping and not navigating, you can start with post-processing.

What kind of accuracy can I expect with a good GPS unit?

In differentially correctable mapping grade systems (Mapping grade systems are those designed to collect GIS feature, attribute and value data and which support point, line and polygon collection), you will find two basic categories of accuracy after correction has occurred (REMINDER....regardless of post-process or real-time the accuracy will be about the same).

1) 1-5 meter e.g. Trimble GeoExplorer, CMT March and MC-GPS (your options are limited in this category of mapping grade system)

2) sub-meter eg. Trimble ProXR, Leica GS50 Ashtech Reliance, CMT HP-GPS-L4

These accuracies assume typical accuracy with good GPS conditions. I have seen "sub-meter" GPS system produce 6 - 7 meter or worse accuracy under undesirable GPS conditions. Centimeter accuracy systems are also available. They are generally used for surveying and are prohibitively expensive for most organizations.

How much can I expect to pay for a mapping grade GPS system?

If you want to get 1 to 5 meter accuracy with the ability to perform post processing expect to pay about $3-4,000. Expect to pay $4-5,000 for a 1 to 5 meter real time beacon system. If you must get below one meter accuracy and you have the money, expect to pay about $8500 for a sub-meter system with post-processing and about $10,000 for a sub-meter system with a real-time beacon receiver.

Also see Appendix A: Summary Table of Different GPS Receivers from the December 2000 Project Report Titled: Comparison of GPS Receivers Under a Forest Canopy with Selective Availability Off from the USDA Forest Service available at:

http://www.fs.fed.us/database/gps/mtdc/gps2000/gps_comparison.htm

Aren't there other important factors besides accuracy when comparing GPS systems?

Here are some other considerations to look for in a GPS system:

- What type of data do I want to collect (points, lines, areas, all of the above?).
- How do I want to describe that data (simple label or full GIS

- feature/attribute/value descriptions)?

- Where am I ultimately sending my data? Make sure you have the tools to efficiently transfer, post-process (if necessary), quality control and edit, and export to your desired software package. Evaluate the time you will spend with the data as a cost just as much as the front-end outlay on the equipment.

I have a GPS unit that I got at REI for $150 and it picks up more satellites than the Trimble Pro XR at the office. What's going on?

Satellite tracking capability and accuracy are two very different things. A system that can appear to acquire satellites more easily many be doing so by compromising signal integrity and therefore accuracy. This is why some recreational GPS will track satellites more easily than more precise systems. Additionally, Mapping Grade Systems have many extra GPS settings that Recreational units do not and many users fail to understand the effects of these settings. These settings will impact the tracking versus data quality/accuracy trade off.

Data Collection Tips

- Always write down name of rover file in field notebook or any name changes.

- Get 5 satellites whenever possible for data collection, especially in mountainous terrain.

- When collecting points get a minimum of 10 for point settings, and 1 point every 5 feet or so for line and polygon settings.

- Always pause the data collector when you get enough points to save space.

- Never use pause for lines or polygons when you stop and move to another feature this will cause a line to be drawn between the two points.

- Enter feature and start again this will eliminate any unneeded line segments.

- Move slowly through heavy canopy and listen for the beeps of the data collector gathering points, if it stops collecting points stop and wait until the unit can start receiving the signal again you may have to move a couple feet to reacquire the signal.

- Stay away from large man-made objects if possible these will cause multi-path.

- Check the Web to find what times of day are best for getting satellite signals. (See Pre Project Planning)

Further Studies

The following websites are good sources for more in depth information on GPS:

http://www.colorado.edu/geography/gcraft/notes/gps/gps.html
http://www.trimble.com/gps/howgps/gpsfram1.htm
http://www.garmin.com/manuals/gps4beg.pdf
http://164.214.2.59/nimahome.html
http://ares.redsword.com/gps/
http://www.howstuffworks.com/brain

Appendix A: Summary Table of Different GPS Receivers

From the December 2000 Project Report Titled: Comparison of GPS Receivers Under a Forest Canopy with Selective Availability Off from the USDA Forest Service.

Receiver	Advantages	Disadvantages	Accuracy (Typical)	Approx. Cost
Trimble Pro XR	Can log Data Can Post Process Can export data to Arc/Info Real-Time DGPS Accuracy	Cost Bulky	Open Canopy 1-4 m Under Canopy 2 – 5 m	$10,000
Trimble Geo 3	Can log Data Can Post Process Can export data to Arc/Info Real-Time DGPS	Cost Not as accurate as Pro XR Should use External antenna	Open Canopy 1-4 m Under Canopy (120 positions) Lubrecht 2.4 – 7.7 m Post-Processed 2.5 – 7.8 m	$4,500
Rockwell PLGR	Acquires GPS Signal in difficult canopy and terrain better than C/A signal Simple to Use	Must record positions manually. Doesn't log data without external data logging device. Can't Post Process Can do Real-Time processing but then uses the C/A signal. Accuracy not as good as post processed other receivers. A military accountable item. Must be re-keyed annually.	Open Canopy 1-4 m Under Canopy (120 positions) Lubrecht 2.5 – 6 m	$3,500 Ext. Ant. +$300
Trimble Centurion	Acquires GPS Signal in difficult canopy and terrain better than C/A	Can use Asset surveyor software and TDC1 data logger	Open Canopy	$4,900

	signal Simple to Use	to collect data. Can't Post-Process "P" code data. Can do Real-Time processing but then uses the C/A signal. Accuracy not as good as post processed other receivers. A military accountable item. Must be re-keyed annually.	1-4 m Under Canopy (120 positions) Lubrecht 2.5 – 6 m	Ext. Ant. +$300
Garmin III+	Cost Ease of Use Readily available Records Waypoints and can download to their software Can do Real-Time DGPS with extra optional receiver with some work Can Average Waypoints	Can't export data into ARC/Info Can't Post Process Should use External antenna	Open Canopy 1-4 m Under Canopy (Ave 120 positions) 2.5 – 12 m	$350-Unit Soft. & Ext. Ant +$200 DGPS +$300
Magellan 400	Cost Ease of Use Readily available Records Waypoints and can download to their software Can do Real-Time DGPS with extra optional receiver with some work Can average waypoints	Can't export data into ARC/Info Can't Post Process Should use External antenna Waypoint Averaging is tricky – starts when receiver quits moving	Open Canopy 2-7 m Under Canopy Lubrecht (60 position average) 3 – 15 m	$350 - Unit Software $60+ Ant $100

Table 1. **Comparison of various Receivers** ***Preliminary only***

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December 2000 Project Report: Comparison of GPS Receivers Under a Forest Canopy with Selective Availability

The full report can be viewed at:

http://www.fs.fed.us/database/gps/mtdc/gps2000/gps_comparison.htm

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The information in the frequently asked questions section is mostly based on information provided by Richard Ash in a discussion on the Conservation GIS List Server. (`LISTSERV@PETE.URI.EDU`)

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